R. C. A. Prior.

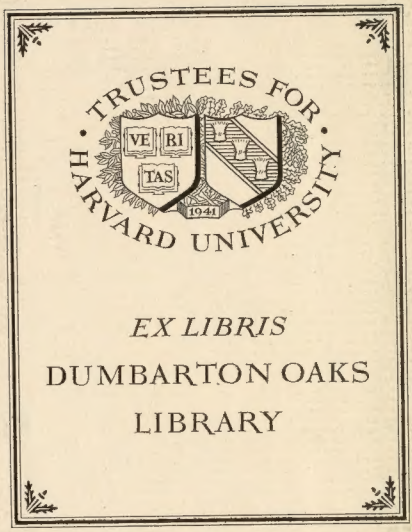

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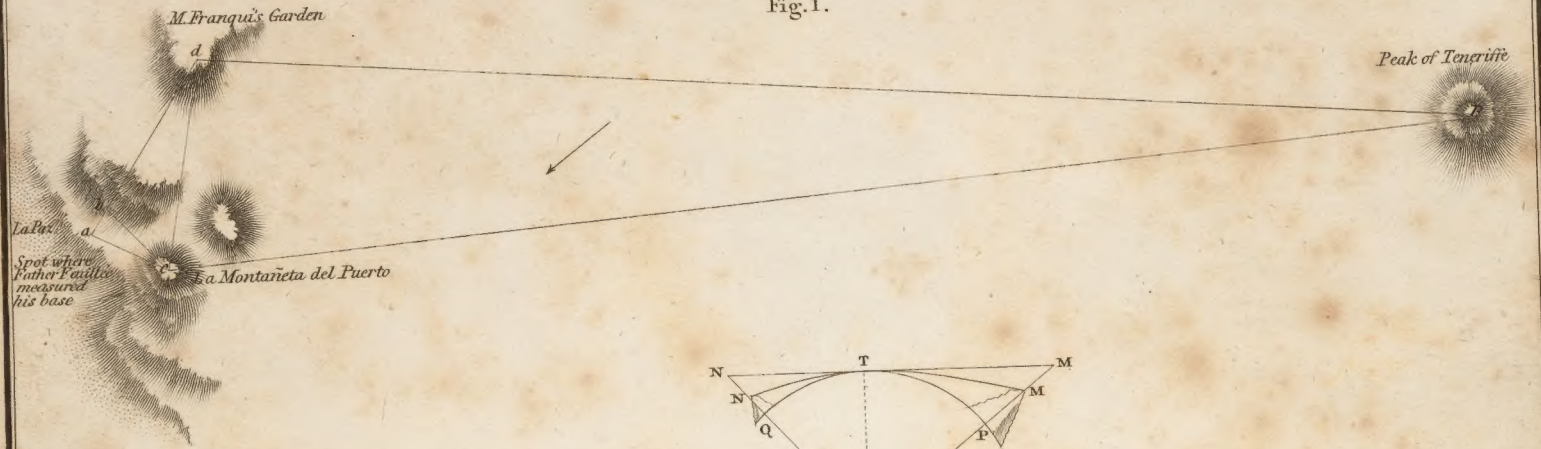
Fig. 1.



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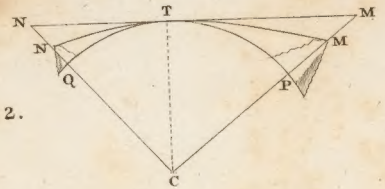

Neele sc. Strand.

Personal Narrative

OF TRAVELS

TO THE

EQUINOCTIAL REGIONS

OF THE

NEW CONTINENT,

DURING THE YEARS 1799—1804,

BY

ALEXANDER DE HUMBOLDT,

AND

AIMÉ BONPLAND;

WITH MAPS, PLANS, *&c.*

WRITTEN IN FRENCH BY

ALEXANDER DE HUMBOLDT,

AND TRANSLATED INTO ENGLISH BY

HELEN MARIA WILLIAMS.

VOL. I.

LONDON:

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1814.

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PREFACE.

After having so long withdrawn myself from the public eye, it is only under the auspices of the following work, that I should have ventured to appear once more in its presence.

The narratives of travellers, and, above all, the description of those remote countries of the globe, which have immortalized the name of Cook, have always had a particular attraction for my mind; and led me in my early youth, to weave an humble chaplet for the brow of that great navigator, which my venerable friend, Doctor Kippis, inserted in the history of his life. The narrative of Cook's glorious

career derives a peculiar charm from presenting to us new systems of social organization; but it must be admitted, that in general sea-expeditions have a certain monotony, which arises from the necessity of continually speaking of navigation in technical language. The mariner also, while he braves the element on which he steers his perilous course, is chiefly occupied by its dangers. The outlines and the bearings of coasts are the leading objects of his researches; he visits only the shores of the countries where he disembarks, and holds but slight communications with the natives by whom they are peopled.

The history of journies by land in distant regions is far more calculated to excite general interest; not only by extending the limits of science, but by presenting new aspects of the variegated scenery of the Globe. Happy the traveller, with whom the study of Nature has not

been merely the cold research of the understanding, in the explanation of her properties, or the solution of her problems! who, while he has interpreted her laws, has adored her sublimity, and followed her steps with passionate enthusiasm, amidst that solemn and stupendous scenery, those melancholy and sacred solitudes, where she speaks in a voice so well understood by the mysterious sympathy of the feeling heart. With what soothing emotions, what eager delight, do we follow the traveller, who leads us from the cares, the sorrows, the joys of ordinary life, to wander in another hemisphere! to mark unknown forms of luxuriant beauty, and unknown objects of majestic greatness—to view a new earth, and even new skies! from which the stars known from childhood, the stars of home, have disappeared, and are succeeded by a foreign firmament. How often will posterity also turn from the terrible page of our history, to repose

on the charm of a narrative, which displays the most enlarged views of science and philanthropy! What sympathy does the traveller excite, while he imprints the first step, that leads to civilization and all its boundless blessings, along the trackless desert, and, struggling with the savageness of the untamed wilderness, obtains a victory that belongs to mankind.

It were erroneous to believe, that countries, because they have been already visited, are therefore known. A penetrating and capacious mind finds every where new materials for observation. The work, of which I now offer the translation to the public, relates to regions of which the greater part have never till now been described by a scientific and learned traveller. A few botanists had indeed herbalized along those distant coasts, and added some riches to the vegetable world. La Condamine, Don Jorge Juan, and Bouguer, scaled the lofty Andes; but it was only to

measure their height, and make astronomical observations. Their journals, which date farther back than half a century, were written when geology did not exist as a science, and the physical structure of those giants of our Globe was yet unknown.

What has hitherto been wanting is now accomplished. M. de Humboldt has in this work displayed, more than in any other he has yet published, his peculiar manner of contemplating nature in all her overwhelming greatness. The appropriate character of his writings is the faculty he possesses of raising the mind to general ideas, without neglecting individual facts; and while he appears only to address himself to our reason, he has the secret of awakening the imagination, and of being understood by the heart.

The general picture, which he has drawn of the Isle of Teneriffe, and the geography of its plants, proves, that in objects often

viewed by others he has seen what they had failed to discern; and in almost the whole of the remainder of his travels he pursues alone the difficult path of scientific discovery. From the Canary Islands he passes to Cumana, New Andalusia, and the missions of the Indians, Chaymas, the province of the Caraccas, the banks of the Apure and the Rio Negro, to the limits of Brazil, New Grenada, the Andes of Popayan, Porto, Quito, and Peru, the western part of the Amazons, Mexico, and the Isle of Cuba. How majestic is nature in the forest and on the banks of the Oronoco! the communications of which flood with that of the Amazons M. de Humboldt has astronomically laid down and determined.

This great work will now soon be terminated. M. de Humboldt remains in Paris for this purpose, with the permission of his own government.

In becoming his interpreter in the text

of the Picturesque Atlas, and the Personal Narrative of his voyage, I have been encouraged by the care with which he has read most of my pages, and corrected many of my errors. My scanty knowledge of the first principles of science seemed indeed to preclude the full comprehension of many of the subjects of which he treats; but a short experience convinced me, that what is clearly expressed may be clearly understood; and I shall perhaps be pardoned, if, from the novelty of the subject, neologisms sometimes occur. Long a stranger to my country, I have indeed no critical favour to expect; I mean that species of favor, which arises from personal acquaintance, and, perhaps even unknowing to the critic himself, softens the stern brow of reproof, and leads him unconsciously to be indulgent, when he only meant to be just. I have nothing to hope from such predilection. My literary patrons belonged to what Ossian calls "the days

of other years." Above all, the learned protector of my early pen, he, whom I have already mentioned, and of whom I never think without emotion, is long since no more! But in appearing before an English tribunal, I will not fear injustice, if I have nothing to hope from partiality; and whatever may be the fate of my imperfect copy of a sublime model, I shall never feel, that the moments were mispent, which I have employed in so soothing, and so noble a task.

HELEN MARIA WILLIAMS.

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INTRODUCTION.

TWELVE years have elapsed since I quitted Europe, to examine the interior of the new continent. Devoted from my earliest youth to the study of nature, feeling with enthusiasm the savage beauties of a country guarded by mountains, and shaded by ancient forests, I experienced in my travels such enjoyments, as have amply compensated for the privations inseparable from a laborious, and often agitated life. These enjoyments, which I endeavoured to impart to my readers in my Remarks upon the Steppes, and in the Essay on the Physiognomy of Plants, were not the only fruits I have reaped from an undertaking, formed with the design of contributing to the progress of natural philosophy. I had long prepared myself for these observations which were the principal objects of my

voyage to the torrid zone. I was provided with instruments of easy and convenient use, constructed by artists of the highest reputation ; and I enjoyed the special protection of a government, which, far from presenting obstacles to my investigations, constantly honored me with every mark of regard and confidence. I was aided by a courageous and enlightened friend, and, what is singularly propitious to the success of participated labor, whose zeal and equanimity never failed, amidst the fatigues and dangers to which we were sometimes exposed.

Under such favorable circumstances, traversing regions which for ages have remained almost unknown to the greatest part of the nations of Europe, I might add even to Spain, we have collected, M. Bonpland and myself, a considerable number of materials, the publication of which may throw some light on the history of nations, and the knowledge of nature. Our inquiries having been directed towards a great variety of objects, we have been unable to present the result under the common form of an itinerary, and have there-

fore consigned our observations in a series of separate works, compiled in the same view, and connected with each other by the nature of the phænomena which they explain. This sort of composition betrays more readily the imperfection of partial labors, and therefore is unfavorable to the self-love of the traveller, but it is highly preferable for whatever relates to the physical and mathematical sciences, because the different branches of those sciences are seldom cultivated by the same class of readers.

I had in view a double purpose in the travels, of which I now publish the historical narrative. I wished to make known the countries I had visited; and to collect such facts as are fitted to elucidate a science, of which we have possessed scarcely the outline, and which has been vaguely denominated *natural history of the world*, *theory of the Earth*, or physical *geography*. The last of these two objects seemed to me the most important. I was passionately devoted to botany, and certain parts of zoology, and I flattered myself that our investigations might add some new species

to those which have been already described; but preferring the connection of facts, which have been long observed, to the knowledge of insulated facts, although they were new, the discovery of an unknown genus seemed to me far less interesting than an observation on the geographical relations of the vegetable world, on the migration of the *social* plants, and the limit of the height which their different tribes attain on the flanks of the Cordilleras.

The natural sciences are connected by the same ties that link all the phænomena of nature. The classification of the species which we ought to consider as the fundamental part of botany, and the study of which is become more attractive and more easy by the introduction of natural methods, is to the geography of plants, what descriptive mineralogy is to the indication of the rocks which constitute the exterior crust of the globe. To comprehend the laws which are observed in the position of these rocks, and determine the age of their successive formations, and their identity in the most distant regions, the geologist ought to be

previously acquainted with the simple fossils, which compose the mass of mountains, and of which the names and character are the object of oryctognostical knowledge. It is the same with that part of the natural history of the globe, that treats of the relations the plants have to each other, with the soil whence they spring, or the air which they inhale and modify. The progress of the geography of plants depends in a great measure on that of descriptive botany; and it would be injurious to the advancement of the sciences to attempt rising to general ideas, in neglecting the knowledge of particular facts.

I have been guided by these considerations in the course of my inquiries; they were always present to my mind at the period of my preparatory studies. When I began to read the numerous relations of voyages, which compose so interesting a part of modern literature, I regretted that travellers, the most enlightened in the insulated branches of natural history, were seldom possessed of a sufficient variety of knowledge, to avail themselves of every advantage arising from their position. It ap-

peared to me, that the importance of the results hitherto obtained did not keep pace with the immense progress, which several parts of science, and particularly geology, the history of the modifications of the atmosphere, and the physiology of animals and plants, had made at the end of the eighteenth century. I saw with regret, and all scientific men have shared this sentiment, that whilst the number of accurate instruments was daily increasing, we were still ignorant of the height of so many mountains and elevated plains; of the periodical oscillations of the aerial ocean; the limit of perpetual snows under the polar circle, and on the borders of the torrid zone; the variable intensity of the magnetic forces, and so many other phænomena, equally important.

Maritime expeditions, voyages round the world, have conferred just celebrity on the names of those naturalists and astronomers, who have been appointed by governments to encounter the dangers they present; but while those distinguished persons have given precise notions of the external configuration of countries, of the

natural history of the ocean, and of the productions of islands and coasts, their expeditions seem less fitted to advance the progress of geology, and other parts of general physics, than travels into the interior of a continent. The advancement of the natural sciences has been subordinate to that of geography and nautical astronomy. During a navigation of several years, the land but seldom presents itself to the observation of the mariner; and when, after lengthened expectation, it is descried, he often finds it stripped of its most beautiful productions. Sometimes beyond a barren coast he perceives a ridge of mountains covered with verdure, but its distance forbids his examination, and the view serves only to increase his regrets.

Journeys by land are attended with considerable difficulty in the carriage of instruments and collections, but these difficulties are compensated by real advantages, which it would be useless to enumerate. It is not by sailing along the coast, that we can discover the direction of the chains of mountains, and their geological constitution, the climate of each zone, and its in-

fluence on the forms and the habits of organized beings. In proportion to the breadth of the continents, the greater is the display on the surface of the soil, of the richness of the animal and vegetable productions; the more distant the central chain of mountains from the shores of the ocean, the greater variety we find, in the bosom of the Earth, of those stony strata, the regular succession of which unfolds to us the history of our planet. In the same manner, as every being considered apart is impressed with a particular type, we find the same impression in the arrangement of brute matter organized in rocks, in the distribution and mutual relations of plants and animals. The great problem of the physical description of the globe, is the determination of the form of these types, the laws of their relations with each other, and the eternal ties which link the phænomena of life, and those of inanimate nature.

In explaining the motives which engaged me to undertake an expedition into the interior of a continent, I merely state the general direction of my ideas at an age

when we have not obtained a just estimate of our faculties. The plans of my early youth have been very incompletely executed. My journey has not had all the extent, which I proposed when I sailed for South America; nor has it furnished the number of general results, which I had hoped to obtain. The court of Madrid had granted me in 1799 permission to embark on board the galleon of Acapulco, and visit the Marian and Philippine islands, after traversing the colonies of the new continent. I had then purposed to go back to Europe by the great Archipelago of Asia, the Persian Gulf, and the way of Bagdad. I shall find occasion hereafter to state the reasons, which determined me to hasten my return. With respect to the works which M. Bonpland and myself have published, we hope that their imperfection, of which we are conscious, will be attributed neither to a want of zeal during the progress of our researches, nor to precipitation in the publication of our labors. A determined will and active perseverance are not always sufficient to surmount every obstacle.

Having stated the general object I had in view in my expeditions, I shall hasten to give a slight sketch of the whole of the collections and observations which we have accumulated, and the union of which is the aim and end of every scientific journey. The maritime war, during our abode in America, having rendered the communications with Europe very uncertain, we found ourselves compelled, in order to diminish the chance of losses, to form three different collections. Of these, the first was embarked for Spain and France, the second for the United States and England, and the third, which was the most considerable, remained almost constantly under our eyes. Towards the close of our expedition, this last collection formed forty two boxes, containing an herbal of six thousand equinoctial plants, seeds*, shells,

* Among the plants which we have introduced into the different gardens of Europe, I shall cite here, as worthy the attention of botanists, the following species. Lobelia fulgens, l. splendens, caldasia heterophylla, (bonplandia geminiflora, Cav.), maurandia antirrhiniflora, gyrocarpus americana, Jacq., cæsalpinia cassioides, salvia cæsia, cyperus nodosus, fa-

insects, and, what had hitherto never been brought to Europe, geological specimens from the Chimborazo, New Grenada, and the banks of the river of the Amazons.

After the journey to the Orinoco, we left a part of these objects at the island of Cuba, in order to take them on our return from Peru to Mexico. The rest followed us during the space of five years, on the chain of the Andes, across New Spain, from the shores of the Pacific Ocean to the West Indian seas. The conveyance of these objects, and the minute care they required, occasioned us such embarrassments as would scarcely be conceived, by those even who

gara lentiscifolia, heliotropium chenopodioides, convolvulus bogotensis, c. arborescens, ipomœa longiflora, solanum Humboldti, Willd., dichondra argentea, pitcairnia furfuracea, cassia pendula, c. mollissima, c. prostrata, c. cuspidata, euphorbia Humboldti, Willd., ruellia fœtida, sisyrinchium tenuifolium, sida cornuta, s. triangularis, phaseolus heterophyllus, glycine precatoria, g. sagittata, palea bicolor, psoralea divaricata, myrica mexicana, atriplex linifolia, inga microphylla, acacia diptera, a. flexuosa, a. patula, a. brachyacantha, a. ciliata, a. acicularis, a. peruviana, a. edulis, and several varieties of georgines. (See *Willdenow Enum. plant. hort. Berol.* 1809.

have traversed the most uncultivated parts of Europe. Our progress was often retarded by the threefold necessity of dragging after us, during expeditions of five or six months, twelve, fifteen, and sometimes more than twenty loaded mules, exchanging these animals every eight or ten days, and superintending the Indians who were employed in leading so numerous a caravan. Often, in order to add to our collections of new mineral substances *, we

* The mineral and vegetable substances which we have brought from America, several of which were till then unknown, have been submitted to chemical analysis by M.M. Vauquelin, Klaproth, Descotils, Allen, and Drapier, who have given descriptions of them in separate memoirs. I shall here mention two new mineral *species:* The feuer-opal, or quartz resinite miellé of Mexico (*Klaproth, chem. Unters. der Min. T.* 4, *p.* 156. *Sonneschmidt Beschr. der Mex. Bergref. S.* 119. *Karsten min. Tabellen,* 1808, *p.* 26, 88.) and the conchoidal muriated silver of Peru, muschliches hornerz (*Klapr. IV,* 10. *Karst, p.* 60, 97. *Magazin der Berl. Naturf. I,* 158); the silver ore, *paco* of Pasco (*Klapr. IV,*) the antimonial gray copper ore, graugultigerz of Tasco (*Kl. IV,* 74); the meteoric iron, meteoreisen, of Durango (*Kl. IV,* 101); the ferriferous carbonated limestone, stænglicher braunspath, of Guanaxuato, the crystals of which reunited in bars form equilateral triangles (*Kl. IV,*

found ourselves obliged to throw away others, which we had collected a considerable time before. These sacrifices were not less painful than the losses which we accidentally made. Sad experience taught us but too late, that from the sultry humidity of the climate, and the frequent falls of the beasts of burden, we could preserve nei-

199); the obsidians of the Knife mountain of Moran, and the pierre perlée, perlstein of Cinapecuaro (*Descotils, Annales de Chimie, LIII,* 260); concrete oxidated tin, (wood tin) of Mexico (*Descotils, Ann. LIII,* 266); the brown lead-ore of Zimapan (*Descotils, Ann. LIII,* 268); the celestine of Popayan and the wavellite, or hydrargillite; a pepite of platina of Choco, weighing 1088·8 grains, which is 18·947 specific gravity (*Karsten,* 96); the moya of Pelileo, a volcanic combustible substance, containing feldspath (*Klapr. IV,* 289); the guano of the islands of Peru, containing urat of ammonia (*Klapr. IV,* 299. *Fourcroy et Vauquelin, Mem. of the Inst. VI,* 369); the dapiché of the river Temi, a species of white caoutchouc, which is found at the depth of three or four feet in a damp soil (*Allen, Journ. Phys. Liv. XVII.* 77); the tabasheer of the bamboos of America, different from that of Asia (*Vauquelin, Mem. de l'Instit. VI,* 382); the cortex Angusturæ, bark of the bonplandia trifoliata of Carony; the cinchona condaminea of Loxa, and several other species of cinchina, which we collected in the forests of New Grenada (*Vauquelin, Ann. LIX,* 137.)

ther the skins of animals too hastily prepared, nor the fishes and reptiles placed in phials filled with alcohol. I have thought proper to enter into these details, which, although little interesting in themselves, prove that we had no means of bringing back, in their natural state, many objects of zoology and comparative anatomy, of which we have published descriptions and drawings. Notwithstanding some obstacles, and the expense occasioned by the carriage of these articles, I had reason to applaud the resolution I had taken before my departure, of sending to Europe the duplicates only of the productions we had collected. I cannot too often repeat, that when the seas are infested with privateers, a traveller can be sure only of the objects in his own possession. A very small number of the duplicates, which we shipped for the ancient continent during our abode in America, were saved; the greater part fell into the hands of persons unknown to science. When a ship is condemned in a foreign port, boxes containing only dried plants or stones, far from being sent to the scientific men to whom they are addressed,

remain consigned to oblivion. Some of our geological collections taken in the Southern Ocean had, however, a happier fate. We were indebted for their preservation to the generous activity of Sir Joseph Banks, President of the Royal Society of London, who, admidst the political agitations of Europe, has unceasingly labored to strengthen the ties by which are united the scientific of all nations.

The same causes, which checked our communications, have contributed also to form numerous obstacles, since our return, to the publication of a work, which from its nature must be accompanied by a considerable number of engravings and maps. If such difficulties are sometimes encountered in undertakings made at the expense, and by the munificence of governments, how much more must they be felt by private individuals! It would have been impossible for us to have surmounted them, if the liberal zeal of the editors had not been seconded by the extreme favor of the public. More than two thirds of our work are already published. The maps of the Orinoco, of the Cassiquiare, and of the

river Magdalena, founded on my astronomical observations, together with several hundred plants, are engraved and ready to appear. I shall not leave Europe to undertake an expedition into Asia, till I have laid before the public the whole result of my travels in the New Continent.

In the memoirs in which we have investigated the various objects of our remarks, we have considered each phenomenon under different aspects, and classed our observations according to the relations which they bear to each other. To give a just idea of the method we have followed, I shall here add a succinct enumeration of the materials, with which we were furnished for describing the volcanoes of Antisana and Pichincha, as well as that of Jorullo, which in the night of the 20th of September 1759 rose from the earth one thousand five hundred and seventy-eight French feet above the surrounding plains of Mexico. The position of these singular mountains in longitude and latitude was ascertained by astronomical observations. We took the heights of the different parts by the aid of the barometer, and determined the dip

of the needle and the intensity of the magnetic forces. Our collections contain the plants which are spread on the flanks of these volcanoes; and specimens of different rocks, which, piled on each other, constitute their external coat. We are enabled to indicate by measures sufficiently exact the height above the level of the ocean, at which we found each group of plants, and each volcanic rock. Our journals furnish us with a series of observations on the humidity, the temperature, the electricity, and the degree of the transparency of the air on the brinks of the craters of Pichincha and Jorullo; the topographical plans and the geological profiles of these mountains, founded in part on the measure of vertical bases, and on angles of altitude. Each observation has been calculated according to the tables and the methods, which are considered as the most exact in the actual state of our knowledge; and in order to judge of the degree of confidence which the results may claim, we have preserved the whole detail of our partial operations.

It would have been possible to blend

these different materials in a work devoted wholly to the description of the volcanoes of Peru and New Spain. Had I given the physical description of a single province, I could have treated separately what relates to geography, mineralogy, and botany; but how could I interrupt either the narrative, a disquisition on the manners, the aspect of nature, or the great phænomena of general physics, by the fatiguing enumeration of the productions of the country, the description of new species of animals and plants, or by the dry detail of astronomical observations? Had I adopted a mode of composition, which should have contained in the same chapter all that has been observed on the same point of the globe, I should have composed a work of cumbrous length, and devoid of that clearness, which arises in a great measure from the methodical distribution of the matter. Notwithstanding the efforts which I have made to avoid, in this narration of my journey, the errors I had to dread, I feel conscious, that I have not always succeeded in separating the observations of detail from those general consequences, which interest every en-

lightened mind. These results comprise in one view the climate, and its influence on organized beings, the aspect of the country, varied according to the nature of the soil and its vegetable covering, the direction of the mountains, and the rivers which separate the races of men as well as the tribes of vegetables; and finally, those modifications, which the state of nations, placed in different latitudes, and in circumstances more or less favourable to the display of their faculties undergoes. I am not afraid of having too much enlarged on objects so worthy of attention: one of the noblest privileges, which distinguish modern civilization from that of remoter times, is the having enlarged the mass of our conceptions, having rendered us more capable of perceiving the connection between the physical and intellectual world, and having thrown a more general interest over objects, which heretofore occupied only a small number of scientific men, because these objects were contemplated separately, and from a narrower point of view.

It is probable that the volumes, which I am now about to publish, will fix the atten-

tion of a greater number of readers, than the detail of observations merely scientific, or than my researches on the population, the commerce, and the mines of New Spain. I may therefore be permitted to enumerate in this place all that we have hitherto published. When several works are interwoven in some sort with each other, it may perhaps be interesting to the reader, to know the sources from which he may obtain more circumstantial information. In the journey of Pallas, which is so remarkable for the precision and depth of his researches, the same Atlas contains geographical maps, the costumes of different nations, relicks of antiquity, and figures of plants and animals. In conformity to the plan of our work, we have distributed these plates into distinct parts; having divided them into the two geographical and physical Atlasses, which belong to the narrative of the travels, and the Political Essay on the Kingdom of New Spain; the Views of the Cordilleras, and the monuments of the natives of America; and the Equinoctial plants, the Monography of the Melastomas, and the Collection of zoological observations.

As I shall often be obliged to cite these different works, I shall mention in notes the abbreviations, which I have used to indicate the titles.

I. *Astronomical observations, trigonometrical operations and barometrical measurements made during the course of a journey to the equinoctial regions of the New Continent* from* 1799 *to* 1804. This work, to which are added historical researches on the position of several points important to navigators, contains, first, the original observations which I made from the 12° of southern, to the 41° of northern latitude; the transits of the sun and stars over the meridian; distances of the moon from the sun and the stars; occultations of the satellites; eclipses of the sun and moon; transits of mercury over the disk of the sun; azimuths;

* Astron. Observations, two volumes in 4to. I have discussed in the introduction, placed at the head of this work, the choice of the most proper instruments to employ in distant journies, the degree of precision that can be obtained in the different kinds of observations, the peculiar motions of certain great stars of the southern hemisphere, and several methods, the use of which is not sufficiently common among navigators.

circum-meridian altitudes of the moon, to determine the longitude by the differences of the declination; researches on the relative intensity of the light of the austral stars; geodesical measures, &c. Secondly, a treatise on the astronomical refractions under the torrid zone, considered as the effect of the decrement of caloric in the strata of the air; thirdly, the barometric measurement of the Cordillera of the Andes, of Mexico, of the province of Venezuela, of the kingdom of Quito, and of New Grenada; followed by geological observations, and containing the indication of four hundred and fifty-three heights, calculated, according to the method of Mr. Laplace, and the new coefficient of Mr. Ramond; fourthly, a table of near seven hundred geographical positions on the New Continent; two hundred and thirty-five of which have been determined by my own observations, according to the three coordinates of longitude, latitude, and height.

II. *Equinoctial plants collected in Mexico, in the Isle of Cuba, in the provinces of Caraccas, Cumana, and Barcelona, on the Andes of New Grenada, Quito, and Peru,*

*and on the banks of the Rio Negro, the Orinoco, and the river of Amazons**. Mr. Bonpland has given the figures of more than forty new genera† of plants of the torrid zone, classed according to their natural families. The methodical descriptions of the species are both in French and in Latin, and accompanied by observations on the medicinal properties of the plants, on their use in the arts, and on the climate of the countries where they are found.

III. *Monography of the Melastomas, rhexia, and other genera of this order of plants*‡. This work will comprise upwards of a

* Equinoctial plants, 2 vols. folio, with more than 120 plates. This number of plates has been greatly augmented since M. de Humboldt wrote this introduction. The number contained in the two volumes will exceed 150. See the prospectus of M. de Humboldt's works at the end of the volume.

† We shall cite here only the genera, ceroxylon, marathrum, cassupa, saccellium, cheirostemon, rhetiniphyllum, machaonia, limnocharis, bertholetia, exostema, vauquelinia, guardiola, turpinia, salpianthus, hermesia, cladostyles, lilæa, culcitium, espeletia, bonplandia, platycarpum, andromachia, menodora, gaylussaica, podopterus, leucophyllum, angelonia.

‡ Melastomas, 2 vols. folio, with coloured plates.

hundred and fifty species of melastomacea, which we collected during the course of our expeditions, and which form one of the most beautiful ornaments of tropical vegetation. M. Bonpland has added the plants of the same family, which, among so many other rich stores of natural history, M. Richard collected in his interesting expedition to the Antilles and French Guiana, and of which he has communicated to us the descriptions.

IV. *Essay on the geography of plants, accompanied with a physical table of the equinoctial regions, founded on measures taken from the tenth degree of northern to the tenth degree of southern latitude**. I have endeavoured to collect under a single point of view the whole of the physical phænomena of that part of the New Continent, comprised in the torrid zone, from the level of the South Sea to the highest summit of the Andes; namely, the

* This work, printed for the first time in 1806, will be reprinted with additions, and form part of the fifth division of the complete collection, under the title of *General Physics*. I have explained the first ideas of the *geography of plants*, their *natural associations*, and the *history of their migrations*, in my Flora, &c.

vegetation, the animals, the geological facts, the cultivation of the soil, the temperature of the air, the limit of the perpetual snows, the chemical constitution of the atmosphere, its electrical intensity, its barometrical pressure, the decrement of gravitation, the intensity of the azure colour of the sky, the diminution of the light during its passage through the successive strata of the air, the horizontal refractions, and the heat of boiling water at different heights. Fourteen scales, disposed at the side of a profile of the Andes, indicate the modifications which these phænomena undergo from the influence of the elevation of the soil above the level of the ocean. Each group of plants is placed at the height that nature has assigned, and we may follow the prodigious variety of their forms, from the region of the palms and the fern-trees to those of the johannesia (chuquiraga, Juss.) the gramineous plants, and lichens. These regions form the natural divisions of the vegetable empire; and in the same manner as the perpetual snows are found in every climate at a determinate height, the febrifuge species of the quinquina

(cinchona) have also their fixed limits, which I have marked in the botanical chart belonging to this essay.

V. *Collection of observations on zoology and comparative anatomy* *. I have comprised in this work the history of the condor; experiments on the electrical action of the gymnotus †; a treatise on the larynx of the crocodiles, the quadrumani, and birds of the tropics; the description of several new species of reptiles, fishes, birds, monkeys and other mammalia but little known. A distinguished man of science, whose constant friendship has been highly honourable and advantageous to me during a great number of years, M. Cuvier, has enriched the collection with a very extensive treatise on the axolotl of the lake of Mexico, and on the genera of

* *Zoolog. Obs.* two vols, in 4to. The first of these volumes is published with thirty plates, most of which are coloured. The second volume is far advanced.

† These experiments are connected with those I published previous to my departure to America, in the second volume of my essay on the irritability of the nervous and muscular fibre, and on the chemical action which keeps up the life of animals and plants. 1796.

the protei in general. This naturalist has also recognized two new species of mastodontes, and a real elephant, among the fossil bones of quadrupeds which we brought from America*. The description of the insects collected by Mr. Bonpland is due to Mr. Latreille, whose labours have so much contributed to the progress of entomology in our times. The second volume of this work will contain the figures of the Mexican, Peruvian, and Aturian skulls, which we have deposited in the Museum of Natural History at Paris, and on which Mr. Blumenbach has already published observations in the *Decas quinta craniorum diversarum gentium.*

VI. *Political essay on the kingdom of New Spain, with a physical and geographical atlas, founded on astronomical observations, and trigonometrical and barometrical measurement**. This work, found-

* Ann. of the Museum of Nat. Hist. t. 8, p. 57, and pp. 412, 413, pl. 2, figs. 1, 5.

* *Polit. Ess.* &c. in two vols, in 4to, and an Atlas of twenty charts in folio. My *general map of the kingdom of New Spain, formed on astronomical observations, and on the whole of the materials which existed in Mexico in* 1804, has been copied by Mr.

ed on a great number of official memoirs, presents, in six divisions, considerations on the extent and natural appearance of Mexico, on the population, on the manners of the inhabitants, their ancient civilization, and the political division of their territory. It embraces at the same time the agriculture, the mineral riches, the manufactures, the commerce, the finances, and the military defence of this vast coun-

Arrowsmith, who has appropriated it to himself, by publishing it on a larger scale, under the title of *New Map of Mexico, compiled from original Documents, by Arrowsmith.* It is very easy to recognize this map from the number of chalcographical errors with which it abounds, from the explanation of the signs which he has forgotten to translate from the French into English, and from the word *ocean*, which is engraved amidst the mountains, in a place where the original states, that *the elevated plain of Toluca is* 1400 *toises above the level of the ocean.* The conduct of Mr. Arrowsmith is so much the more reprehensible, as neither Messrs. Dalrymple, Rennel, D' Arcy de la Rochette, nor any of those other excellent geographers England boasts, have ever given him the example, either in their maps, or the analyses which accompany them. The reclamations of a traveller must appear just, when mere copies of his labours are published under the names of other persons.

try. In treating on these different objects of political economy, I have endeavoured to consider them under a general point of view; I have drawn the parallel of New Spain, not only with the other Spanish colonies, and the confederation of the United States of North America, but also with the possessions of the English in Asia; I have compared the agriculture of the countries situate under the torrid zone, with that of the temperate climates; and I have examined the quantity of colonial produce necessary to Europe in the present state of its civilization. In tracing the geognostic description of the districts of the richest mines of Mexico, I have given a statement of the mineral produce, the population, the imports, and exports, of the whole of Spanish America; I have, upon the whole, examined several questions, which, for want of precise data, had never hitherto been treated with the importance which they demand; such as those on the influx and reflux of metals*, on their

* The recent travels of Major Zebulon Montgomery Pike, in the northern provinces of Mexico, (*Account of the Expedition to the sources of the Mis-*

progressive accumulation in Europe and Asia, and on the quantity of gold and silver, which, since the discovery of America down to our own times, the old world has received from the new. The geographical

sisippi, and to the interior Parts of New Spain, Philadelphia, 1810) contains valuable notions on the rivers La Platte and Arkansas, as well as on the chain of mountains which extends to the North of New Mexico, towards the sources of these two rivers: but the numerous statistical data, which Mr. Pike has collected in a country of the language of which he was ignorant, are for the greater part very inaccurate. According to this author, the mint of Mexico coins every year 50 millions of piastres in silver, and 14 millions in gold: while it is proved by the tables annually printed by order of the Court, and published in the Political Essay, that, the year in which the produce of the mines was the most abundant, the coinage amounted only to 25,806,074 piastres in silver, and to 1,359,814 piastres in gold. Mr. Pike displayed admirable courage in an important undertaking for the investigation of western Louisiana; but unprovided with instruments, and strictly watched on the road from Santa Fe to Natchitoches, he could do nothing towards the progress of the geography of the *provincias internas.* The maps of Mexico, which are annexed to the narrative of his journey, are reduced from my great map of New Spain, of which I left a copy, in 1804, at the secretary of state's office at Washington.

introduction at the beginning of this work contains the analysis of the materials, which have been used in the construction of the Mexican Atlas.

VII. *Views of the Cordilleras, and monuments of the indigenous nations of the new continent**. This work is meant to display a few of the great scenes of nature in the lofty chain of the Andes, and at the same time throw some light on the ancient civilization of the Americans, from the study of their monuments of architecture, their hieroglyphics, their religious rites, and their astrological reveries. I have given in this work a description of the teocalli, or Mexican pyramids, compared with that of the temple of Belus; the arabesques which cover the ruins of Mitla, idols in basalt, ornamented with the calantica of the heads of Isis; and a considerable number of symbolical paintings, representing the serpent woman, who is the Mexican Eve;

* Monum. Amer. one vol. in folio, with 60 plates, part of which are colored, accompanied by explanatory treatises. This work may be considered as the picturesque Atlas to the historical narrative of the voyage.

the deluge of Coxcox, and the first migrations of the natives of the Azteck race. I have endeavoured to prove the striking analogies which exist between the calendar of the Toltecks, and the catasterisms of their zodiac, and the division of time of the people of Tartary and Thibet; as well as the Mexican traditions on the four regenerations of the globe, the pralayas of the Hindoos, and the four ages of Hesiod. I have also included in this work, in addition to the hieroglyphical paintings I brought back to Europe, fragments of all the Azteck manuscripts, which are found at Rome, Veletri, Vienna, and Dresden, and of which the last reminds us, by its lineary symbols, of the kouas of the Chinese. Together with the rude monuments of the natives of America, the same volume contains picturesque views of the mountainous countries, which these people have inhabited; such as those of the cataract of Tequendama, of Chimborazo, of the volcano of Jorullo, and of Cayambe, the pyramidal summit of which, covered with perennial ice, is situate directly under the equinoctial line. In every zone

the configuration of the ground, the physiognomy of the plants, and the aspect of a smiling or savage nature, have great influence on the progress of the arts, and on the style which distinguishes their productions; and this influence is so much the more perceptible, as man is farther removed from civilization.

I could have added to this work researches on the character of languages which are the most durable monuments of nations. I have collected a number of materials on those of America, of which Messrs. Frederic Schlegel and Vater have made use; the first in his Considerations on the Hindoos, the second in his continuation of the Mithridates of Adelung, in the Ethnographical Magazine, and in his Inquiries into the Population of the New Continent. These materials are now in the hands of my brother, M. William de Humboldt, who, during his journey in Spain, and a long abode at Rome, formed the richest collection of American vocabularies, that has ever existed. His knowledge of the ancient and modern languages being very extensive, he has made some

curious approximations on this object, so important for the philosophical study of the history of man. I flatter myself, that a part of his labors will find a place in this narrative.

Of those different works which I have here enumerated, the second and third were composed by M. Bonpland, from the observations which he made on the spot, in a botanical journal. This journal contains more than four thousand methodical descriptions of equinoctial plants, a ninth part only of which have been made by me, and will appear in a separate publication, under the title of *Nova Genera et Species Plantarum.* In this work will be found not only the new species which we collected, and the number of which, after a long examination by one of the first botanists of the age, Prof. Willdenow, amounts to fourteen or fifteen hundred*, but also the interesting observations

* A considerable part of these species is already inserted in the second division of the fourth part of the Species Plantarum of Linnæus, fourth edition. Of the eringiums, which we brought over from America, eleven new species have been engraved in the beauti-

made by M. Bonpland, on the plants which have hitherto been imperfectly described. The plates of this work will be engraved and executed according to the method followed by M. Labillardiere, in the *Specimen Plantarum Novæ Hollandiæ*, which is a model of sagacity in research, and order in compilation.

The astronomical, geodesical, and barometric observations have been calculated in a uniform manner, by employing correspondent observations, and according to tables of the utmost precision, by Mr. Oltmanns, professor of astronomy, and member of the academy of Berlin; who undertook the publication of my astronomical journal, which he has enriched with the results of his inquiries concerning the geography of America, the observations of Spanish, French, and English travellers, and the choice of the methods used by astronomers. I had calculated, during the course of my journey, two thirds of my own observations, a part of the results of which

ful monography of this genus, published by M. de la Roche.

had been published previous to my return, in the *Connaissance des Temps*, and in the *Ephemerides* of Baron Zach. The trifling differences, which exist between the results obtained by Prof. Oltmanns and myself arise from his having made a more rigorous calculation from the whole of my observations, and his having employed the lunar tables of Burg, and of correspondent observations at Greenwich; while I used only the Connaissance des Temps, calculated from the tables of Masson.

The observations I had made on the dip of the needle, the intensity of the magnetic forces, and the small horary variations of the variation, will appear in a separate treatise, which will be added to my Essay on Geological Pasigraphy. This last work, which I began to compose in Mexico, in 1803, will be accompanied by profiles, indicating the stratification and relative age of the rocks, the types of which were observed by Mr. Leopold Von Buch and myself in the two continents, between the twelfth of southern and the seventy-first of northern latitude. Aided by the labors of this great geologist, who

has examined Europe from the North Cape in Lapland, and with whom I had the happiness of beginning my earliest studies at the school of Freiberg, I have been enabled to extend the plan of a work intended to throw some light on the construction of the Globe, and on the relative antiquity of its formation.

After having distributed into separate works all that belongs to astronomy, botany, zoology, the political description of New Spain, and the history of the ancient civilization of certain nations of the New Continent, there still remained a great number of general results and local descriptions, which I might have collected into separate treatises. I had prepared several during my journey; on the races of men in South America; on the missions of the Orinoco; on the obstacles to the progress of society in the torrid zone, from the climate, and the strength of vegetation; the character of the landscape in the Cordilleras of the Andes, compared with that of the Alps in Switzerland; the analogies between the rocks of the two hemispheres; on the physical constitution of the air in

the equinoctial regions; &c. I had left Europe with the firm intention of not writing what is usually called the historical narrative of a journey, but to publish the fruit of my inquiries in works merely descriptive; and I had arranged the facts, not in the order in which they successively presented themselves, but according to the relation they bore to each other. Amidst the overwhelming majesty of Nature, and the stupendous objects she presents at every step, the traveller is little disposed to record in his journal what relates only to himself, and the ordinary details of life.

I had composed a very brief itinerary during the course of my navigation on the rivers of South America, and in my long journies by land, in which I regularly described, and almost always on the spot, the excursions which I made toward the summit of a volcano, or any other mountain remarkable for its height; but the composition of my journal was interrupted whenever I resided in a town, or when other occupations prevented me from continuing a work, which I considered as hav-

ing only a secondary interest. When I employed myself in the composition, I had no other motive than the preservation of some of those fugitive ideas, which present themselves to a naturalist, the whole of whose life is passed in the open air; to make a temporary collection of such facts, as I had not then leisure to class; and trace the first impressions, whether agreeable or painful, which I received from nature, or from man. Far from thinking at the time, that these pages, precipitatedly composed, would form the basis of an extensive work to be offered to the public, it appeared to me, that my journey, though it might furnish certain data useful to science, would present very few of those incidents, the recitals of which give the principal charm to an itinerary.

The difficulties which I have experienced since my return in the composition of a considerable number of treatises, in order to make known certain classes of phænomena, insensibly overcame my repugnance to write the narrative of my journey. In undertaking this task, I nave been guided by the advice of a number

of respectable persons, who honour me with peculiar kindness. I even perceived, that so distinguished a preference is given to this sort of composition, that scientific men, after having presented in an isolated manner the account of their researches on the productions, the manners, and the political state of the countries through which they have passed, imagine that they have not fulfilled their engagements with the public, till they have written their itinerary.

An historical narrative embraces two very distinct objects; the greater or less important events that have a connection with the purpose of the traveller, and the observations which he has made during his journey. The unity of composition also, which distinguishes good works from those on an ill constructed plan, can be strictly observed only when the traveller describes what has passed under his own eye; and when his principal attention has been fixed less on scientific observations, than on the manners of a people, and the great phænomena of nature. Now, the most faithful picture of manners is that, which best

displays the relations of men toward each other. The character of savage or civilized nature is portrayed either in the obstacles which a traveller meets with, or in the sensations which he feels. It is the man himself that we continually desire to see in contact with the objects that surround him; and his narration interests us the more, when a local tint is spread over the description of the country and its inhabitants. Such is the source of the interest excited by the history of those first navigators, who, led on by intrepidity more than by science, struggled against the elements, while they sought a new world in unknown seas. Such is the irresistible charm which attaches us to the fate of that enterprising traveller *, who, full of enthusiasm and energy, penetrated alone into the centre of Africa, in order to discover amidst barbarous nations the traces of ancient civilization.

In proportion as voyages have been made by persons more enlightened, and whose views have been directed towards researches into descriptive natural history,

* Mungo Park.

geography or political economy, itineraries have partly lost that unity of composition, and that simplicity, which characterised those former ages. It is now become scarcely possible to connect so many different materials with the narration of events; and that part which we may call dramatic gives way to dissertations merely descriptive. The great number of readers, who prefer an agreeable amusement to solid instruction, have not gained by the exchange; and I am afraid, that the temptation will not be great to follow those travellers in their expeditions, who drag along with them a considerable apparatus of instruments and collections.

In order to give greater variety to my work, I have often interrupted the historical narrative by simple descriptions. I first describe the phænomena in the order in which they appeared; and I afterward consider them in the whole of their individual relations. This mode has been successfully followed in the journey of M. de Saussure, whose most valuable work has contributed more than any other to the advancement of the sciences, and often,

amidst dry discussions on meteorology, contains many charming descriptions; such as those of the modes of life of the inhabitants of the mountains, the dangers of hunting the chamois, and the sensations felt on the summit of the higher Alps.

These are details of ordinary life, which it might be useful to note in an itinerary, because they serve to regulate the conduct of those, who afterwards journey through the same countries. I have preserved a few, but have suppressed the greater part of those personal incidents, which offer no interesting situations, and which can be rendered amusing only by the perfection of style.

With respect to the country which has been the object of my investigations, I do not dissemble the great advantages, which those who travel to Greece, Egypt, the banks of the Euphrates, and the islands of the Pacific Ocean, enjoy over those who traverse America. In the ancient world, nations, and the distinctions of their civilization formed the principal figures on the canvass; in the new, man and his produc-

tions almost disappear amid the stupendous display of wild and gigantic nature. The human race here presents but a few remnants of indigenous hordes, slightly advanced in civilization; or that uniformity of manners and institutions, which has been transplanted by European colonists to foreign shores. What relates therefore to the history of our species, to the various forms of government, to the monuments of the arts, to those places which are full of great remembrances, affect us far more than the descriptions of those vast solitudes, which seem destined only for the display of vegetable life, and to form the domain of wild animals. The savages of America, who have been the object of so many systematic reveries, and on whom M. Volney has lately published some highly just and sagacious observations, inspire less interest, since celebrated navigators have made known to us the inhabitants of the islands of the South Sea, in whose character we find so striking a mixture of perversity and meekness. The state of half-civilization, in which those islanders are found, gives a

peculiar charm to the description of their manners. Here a king, followed by a numerous suite, comes and presents the fruits of his orchard; there, the funereal festival imbrowns the shade of the lofty forest. Such pictures, no doubt, have more attraction than those, which portray the solemn gravity of the inhabitant of the banks of the Missouri or the Maranon.

If America occupies no important place in the history of mankind, and of the ancient revolutions which have agitated the human race, it offers an ample field to the labours of the naturalist. On no other part of the Globe is he called upon more powerfully by nature, to raise himself to general ideas on the cause of the phænomena, and their natural connection. I shall not speak of that luxuriance of vegetation, that eternal spring of organic life, those climates varying by stages as we climb the flanks of the Cordilleras, and those majestic rivers which a celebrated writer* has described with so much grace-

* M. Chateaubriand.

ful precision. The means which the new world affords for the study of geology and natural philosophy in general are long since acknowledged. Happy the traveller who is conscious, that he has availed himself of the advantages of his position, and that he has added some new facts to the mass of those which were already acquired!

It is almost useless to recapitulate what I have already observed in the preface to the equinoctial plants, that, connected by the most intimate ties of friendship with M. Bonpland, during the course of our travels and the years that have followed, we publish in common the whole of the works, which are the fruit of our labours. I have endeavoured to explain the facts, such as we observed them together; but this narrative having been composed by myself, from notes written by me on the spot, whatever errors may be found in my recital must be attributed to myself alone.

The observations we made during the course of our journey have been distributed into six sections: the first comprehends

the historical narrative; the second zoology and comparative anatomy; the third, the political essay on the kingdom of New Spain; the fourth, astronomy; the fifth, physics and geology; and the sixth, the description of the new plants collected in both Americas. The editors have displayed a liberal zeal to render these works worthy of the public attention. I cannot pass over in silence the frontispiece to this itinerary. M. Gerard, with whom I have had the pleasure of being acquainted these fifteen years, has devoted to me some moments of his time, and I feel the value of this public testimony of his esteem and friendship.

I have carefully mentioned in this work the persons, who have had the kindness to communicate to me their observations; and in this introduction I ought to express my gratitude to Messrs. Gay-Lussac, and Arago, my fellow members of the Institute, who have annexed their names to important labours, and who are endowed with that elevation of character, which is so congenial to an ardent love of the sciences. Living

with them on terms of the most intimate friendship, I have had the means of consulting them daily on objects of chemistry, natural history, and several branches of the mathematics. I have already mentioned in the collection of my astronomical observations what I owe to the friendship of Mr. Arago, who, after having terminated the measure of the meridian of Spain, has been exposed to so many dangers; and who unites the talents of an astronomer with those of a geometrician and a naturalist. At the period of my return I discussed particularly with M. Gay-Lussac the different phænomena of meteorology and physical geology, which I had amassed in my journey. For eight years past we have usually dwelt under the same roof in France, Germany, and Italy; we have witnessed together one of the great eruptions of Vesuvius; and have joined our labours on the chemical analysis of the atmosphere, and the variations of terrestrial magnetism. I have been enabled to avail myself of the profound and ingenious views of this chemist, in correcting my ideas re-

specting several objects, of which I treat in the narrative of my journey.

Since I left America, one of those great revolutions, which at certain periods agitate the human race, has burst forth in the Spanish colonies, and seems to prepare new destinies for a population of fourteen millions of inhabitants; spreading itself from the southern to the northern hemisphere, from the shores of Rio La Plata and Chili to the remotest part of Mexico. Deep resentments excited by colonial legislation, and fostered by mistrustful policy, have stained with blood those countries, which had enjoyed during the last three ages what I will not call happiness, but uninterrupted peace. Already at Quito the most virtuous and enlightened citizens have perished victims of devotion to their country. While I am giving the description of regions, the remembrance of which is so dear to me, I meet at every step with places, which recall to my mind the loss of a friend.

When we reflect on the great political agitations of the new world, we observe,

that the Spanish Americans are by no means in so favourable a position as the inhabitants of the United States, prepared for independance by the long enjoyment of constitutional liberty. Internal dissensions are chiefly to be dreaded in regions, where civilization is but slightly rooted; and where, from the influence of climate, the forests may soon regain their empire over cleared lands, if their culture be abandoned. It is also to be apprehended, that, during a long series of years, no foreign traveller will be enabled to traverse the whole of the countries, which I have visited. This circumstance may perhaps add to the interest of a work, that portrays the state of the greater part of the Spanish colonies at the beginning of the 19th century. I may even indulge the hope, under the influence of more soothing ideas, that this work will be thought worthy of attention, when the passions shall be hushed into peace; and when, under the influence of a new social order, those countries shall have made a rapid progress towards public welfare. If then some pages of my book are snatched

rom obl ivi on, the inhabitant of the banks of the Ori noco will behold with extasy, that populo us cities enriched by commerce, and fertile fi elds cultivated by the hands of freemen, adorn those very spots, where, at the time of my travels, I found only impenetrable fore sts, and inundated lands.

JOURNEY

TO THE

EQUINOCTIAL REGIONS

OF

THE NEW CONTINENT

BOOK I.

CHAPTER I.

Preparations.—Instruments.—Departure from Spain.—Landing at the Canary Islands.

When a government undertakes one of those maritime expeditions, which contributes to the knowledge of the globe, and the progress of natural philosophy, there is no obstacle to the accomplishment of its purpose. The time of departure, and the direction of the voyage may be fixed, whenever the vessel is equipped, and astronomers and naturalists are appointed to traverse unknown seas. The islands and coasts, the productions of which these travellers are prepared to examine, are subject to the influence of no European policy. If it

happen that the freedom of the seas be interrupted by lengthened hostilities, passports are mutually granted by the belligerent powers, and partial enmities disappear before the advancement of general knowledge, which is the common cause of all nations. Far different is the situation of a private individual, who undertakes a journey at his own expense into the interior of a continent, over which Europe has extended its system of colonization. The traveller in vain meditates the plan, which he judges the most convenient either for the object of his investigations, or the political state of the country he intends to examine; he collects in vain all his resources, which in distant regions may secure him for a long time an independant existence; his designs are often thwarted by unforseen obstacles, at the moment that he thinks of putting them into execution. Few individuals have had greater difficulties to struggle with than myself, before my departure for Spanish America; I should spare the recital, and begin this narrative by the expedition to the summit of the Peak of Teneriffe, had not the failure of my first projects had a decided influence on the direction I have given my travels since my return from the Orinoco. I shall, however, pass rapidly over those events, which have no interest for science, but which I wish to present in their true light. The curiosity of the public being oftener fixed on the persons of travellers than on their works, what

relates to the first plans I had traced out, has been strangely disfigured*.

From my earliest youth I had felt an ardent desire to travel into distant regions, which Europeans had seldom visited. This desire is the characteristic of a period of our existence, when life appears an unlimited horizon, and when we find an irresistible attraction in the impetuous agitations of the mind, and the image of positive danger. Educated in a country which has no direct communication with the colonies of either India, living amidst mountains, remote from the coasts, and celebrated for their numerous mines, I felt an increasing passion for the sea and distant expeditions. The objects with which we are acquainted only by the animated narratives of travellers have a particular charm; imagination wanders with delight over what is vague and undefined; and the pleasures of which we are deprived seem possessed of a fascinating power, com-

* I here beg leave to observe, that, I never had the slightest knowledge of a work in six volumes, published by Vollmer, at Hamburg, under the strange title of "Voyage round the World, and in South America, by A. de Humboldt." This narrative, which appeared in my name, was compiled, it seems, from accounts given in the public papers, and from memoirs which I read to the first class of the Institute. The compiler, with a view of engaging the attention of the public, thought he might give to an expedition made to some parts of the New Continent the more attractive title of Voyage round the World.

pared to which all we daily feel in the narrow circle of sedentary life appears insipid. The taste for herborisation, the study of geology, rapid excursions to Holland, England, and France, with the celebrated Mr. George Forster, who had the happiness to accompany Captain Cook in his second expedition round the globe, contributed to give a determined direction to the plan of travels, which I had formed at eighteen years of age. No longer deluded by the agitation of a wandering life, I was anxious to contemplate nature in all its variety of wild and stupendous scenery; and the hope of collecting some facts useful to the advancement of science incessantly impelled my wishes towards the luxuriant regions spread under the torrid zone. As my personal situation then prevented me from executing the projects, by which I was so powerfully influenced, I had leisure to prepare myself during six years for the observations I purposed to make on the New Continent, to visit different parts of Europe, and explore the lofty chain of the Alps, the structure of which I might afterwards compare with that of the Andes, of Quito, and of Peru. As I employed successively instruments of different constructions, I fixed my choice on those which appeared to me the most exact, and the least subject to break in the carriage. I had an opportunity of repeating measurements, which had been taken according to the most rigorous methods; and I

learnt from experience the extent of the errors, to which I might be exposed.

I had traversed a part of Italy in 1795, but had not been able to visit the volcanic regions of Naples and Sicily; and I regretted leaving Europe without having seen Vesuvius, Stromboli, and Ætna. I felt, that in order to form a proper judgment of a great number of geological phenomena, especially of the nature of the rocks of trap formation, it became necessary to have examined strictly the phenomena offered by burning volcanoes. I determined therefore to return to Italy in the month of November, 1797. I made a long stay at Vienna, where the fine collections of exotic plants, and the friendship of Messrs. de Jacquin, and of Mr. Joseph Van der Schott were highly useful to my preparatory studies. I travelled with Mr. Leopold de Buch, who has since published an excellent work on Lapland, through several cantons of Salzburgh and Styria, countries alike interesting to the landscape-painter and the geologist; but at the moment I was passing the Tyrolese Alps, the war which raged in Italy obliged me to abandon the project of going to Naples.

A short time before, a person who was passionately fond of the fine arts, and who had visited the coasts of Greece and Illyria to inspect their monuments, made me a proposal to accompany him in an expedition to Upper Egypt. This expedition was to last only eight months: provided with

astronomical instruments and able draughtsmen, we were to ascend the Nile as far as Assouan, after minutely examining the positions of the Saïd, between Tentyris and the cataracts. Though my views had not hitherto been fixed on any region beyond the tropics, I could not resist the temptation of visiting countries so celebrated in the annals of human civilization. I therefore accepted this proposition, but with the express condition, that on our return to Alexandria I should be at liberty to continue my journey through Syria and Palestine. I directed henceforth my studies in conformity to this new project, which I afterward found useful, when I examined the relations between the barbarous monuments of Mexico, and those belonging to the nations of the old world. I thought myself on the point of embarking for Egypt, when political events forced me to abandon a plan, which promised me so much satisfaction. The situation of the East was such, that no individual could hope to pursue operations, which even in the most peaceful times often expose the traveller to the suspicion of its governments.

An expedition of discoveries in the Southern Ocean, under the direction of Captain Baudin, was then preparing in France. The first plan was great, bold, and worthy of being executed by a more enlightened commander. The purpose of this expedition was to visit the Spanish posses-

sions of South America, from the mouth of the river Plata to the kingdom of Quito and the isthmus of Panama. After traversing the Archipelago of the great Ocean, and exploring the coasts of New Holland, from Diemen's Land to that of Nuyts, both vessels were to stop at Madagascar, and return by the Cape of Good Hope. I was at Paris when the preparations for this voyage were begun. I had but little confidence in the personal character of captain Baudin, who had given cause of discontent to the Court of Vienna, when he was commissioned to conduct to Brazil one of my friends, the young botanist, Mr. Van der Schott; but as I could not hope, with my own resources, to make a voyage of such extent, and view so fine a portion of the globe, I determined to take the chances of this expedition. I obtained permission to embark, with the instruments I had collected, in one of the vessels destined for the South Sea, and I reserved to myself the liberty of leaving Captain Baudin, whenever I thought proper. M. Michaux, who had already visited Persia, and a part of North America, and M. Bonpland, with whom I formed a friendship that still unites us, were appointed to accompany this expedition as naturalists.

I had flattered myself during several months with the idea of sharing in labors directed to so great and honorable an object, when the war, which broke out in Germany and Italy, determined

the French government to withdraw the funds granted for their voyage of discovery, and adjourn it to an indefinite period. Cruelly deceived in my hopes, seeing the plans which I had been forming during many years of my life overthrown in a single day, I sought at any risk the speediest means of quitting Europe, and engaging in some enterprise, which might console me for my disappointment.

I became acquainted with a Swedish Consul, Mr. Skioldebrand, who, appointed by his Court to carry presents to the Dey of Algiers, passed through Paris, in order to embark at Marseilles. This estimable man had resided a long time on the coasts of Africa; and being highly respected by the government of Algiers, he could easily procure me permission to visit that part of the chain of the Atlas, which had not been the object of the important researches of M. Desfontaines. He despatched every year a vessel for Tunis, where the pilgrims embarked for Mecca, and he promised to convey me by the same occasion to Egypt. I eagerly seized so favorable an opportunity, and thought myself on the point of executing a plan, which I had formed previous to my arrival in France. No mineralogist had yet examined that lofty chain of mountains, which in the empire of Morocco rises to the limit of the perpetual snows. I flattered myself, that, after executing some useful operations

in the Alpine regions of Barbary, I should receive in Egypt from those illustrious men, who had for some months formed the Institute of Cairo, the same kind attentions, with which I had been honored during my abode in Paris. I hastily completed my collection of instruments, and purchased works which related to the countries I was going to visit. I separated myself from a brother, who by his advice and example had hitherto exercised a great influence on the direction of my thoughts. He approved the motives which determined me to quit Europe; a secret voice assured us, that we should meet again; and that hope, which has not proved delusive, softened the pain of a long separation. I left Paris with the intention of embarking for Algiers and Egypt; but in consequence of one of those vicissitudes, which sway the affairs of this life, I returned to my brother from the river of Amazons and Peru, without having touched the continent of Africa.

The Swedish frigate, which was to convey Mr. Skioldebrand to Algiers, was expected at Marseilles toward the end of October. M. Bonpland and myself repaired thither with so much the more celerity, as during our journey we were tormented with the fear of being too late, and missing our passage. We did not at that time foresee the new impediments that awaited us.

Mr. Skioldebrand was no less impatient than

ourselves to reach his place of destination. Several times a day we climbed the mountain of Notre Dame de la Garde, which commands an extensive view of the Mediterranean. Every sail which we descried in the horizon excited in us the most powerful emotion; but after two months of anxiety, and vain expectation, we learnt by the public papers, that the Swedish frigate, which was to convey us, had suffered greatly in a storm on the coasts of Portugal, and had been forced to enter the port of Cadiz, to refit. This news was confirmed by private letters, assuring us that the Jaramas, which was the name of the frigate, would not reach Marseilles before the Spring.

We had not the courage to prolong our stay in Provence to this period. The country, and especially the climate, were delightful, but the aspect of the sea reminded us of the failure of our projects. In an excursion we made to Hyeres and Toulon, we found in this last port the frigate la Boudeuse, which had been commanded by Mr. de Bougainville in his voyage round the world, fitting out for Corsica. This illustrious navigator had honored me with particular kindness during my stay at Paris, when I was preparing to accompany the expedition of Captain Baudin. I cannot describe the impression made upon my mind by the sight of the vessel which had carried Commerson to the islands of the Southern Sea. There are dispositions of the soul, in which a

painful emotion blends itself with all our feelings.

We still persisted in our intention of visiting the African coasts, and were nearly becoming the victims of this perseverance. A small vessel of Ragusa, on the point of setting sail for Tunis, was at this period in the port of Marseilles; we thought the opportunity favorable to reach Egypt and Syria, and we agreed with the captain for our passage. The vessel was to sail the following day, but a circumstance, trivial in itself, happily prevented our departure. The animals that were to serve us for food, during our passage, were kept in the great cabin. We desired that some changes should be made, which were indispensable for the safety of our instruments; and during this interval we learnt at Marseilles, that the government of Tunis persecuted the French residing in Barbary, and that every person coming from a French port was thrown into a dungeon. Having escaped this imminent danger, we were compelled to suspend the execution of our projects, and resolved to pass the winter in Spain, in hopes of embarking the next spring, either at Carthagena, or at Cadiz, if the political situation of the East permitted.

We crossed Catalonia, and the kingdom of Valentia, in our way to Madrid. We visited the ruins of Tarragona, and those of the ancient Saguntum; and from Barcelona made an excursion

to Montserrat*, the lofty peaks of which are inhabited by hermits, and where the contrast between luxuriant vegetation, and masses of naked and arid rocks, forms a landscape of a peculiar character. I employed myself in ascertaining by astronomical methods the position of several important points for the geography of Spain†, and determined by means of the barometer the height of the central plain‡; and I made several observa-

* Mr. William de Humboldt, who travelled through the whole of Spain, a short time after my departure from Europe, has given a description of this place in the Geographical Ephemerides of Weimar for 1803.

† Astronomical Observations, Vol. 1. Introduction, page 35 to 37, and lib. 1, page 3 to 33. At this period the latitude of Valencia was still several minutes uncertain. I found the cathedral (which Tofino places in 39° 26′ 30″) to be 39° 28′ 42″, latitude, and 0^h 11′ 0·3 ″ longitude. Four years later, Baron de la Puebla and M. Mechain fixed this point by zenith distances taken with a repeating circle, and by the occultations of stars, to be 39° 28′ 37·6″ latitude, and 0° 11′ 0·6′, longitude. At Murviedro (the ancient Saguntum) I determined the position of the ruins of the temple of Diana, near the convent of the Trinitarians. These ruins are in 39° 40′ 26″ lat. and 0^h 10′ 34″ longitude.

‡ See my notice on the configuration of the territory of Spain in the itinerary of M. de la Borde, vol. 1, p. 147. According to M. Bauza, the medium height of the barometer at Madrid is 26 inches 2·4 lines, whence it results, according to the method of M. Laplace, and the new coefficient of M. Ramond, that the capital of Spain is 309 toises (603 metres) above the level of the ocean. This result is nearly the same as that found by Don Jorge Juan, and published by M. La-

tions on the inclination of the needle, and on the intensity of the magnetic forces. The results of these observations have been separately published, and I shall enter into no detail on the natural history of a country, in which I resided only six months, and which has recently been examined by so many well-informed travellers.

On my arrival at Madrid I had reason to congratulate myself on the resolution I had taken to visit the peninsula. Baron de Forell, minister from the court of Saxony, treated me with a degree of kindness, of which I soon felt the value. He was well versed in mineralogy, and had the purest zeal for every undertaking, that promoted the progress of knowledge. He observed to me, that under the administration of an enlightened minister, Don Mariano Luis de Urquijo, I might hope to obtain permission to visit, at my own expense, the interior of Spanish America. After the disappointments I had undergone, I did not hesitate a moment to adopt this idea.

lande, by which the height of Madrid above the level of Paris is 294 toises (Mem. of the Acad. 1776, page 148). The highest mountain of the peninsula is not, as has been hitherto thought, mount Perdu, but the Mulahacen, which forms part of the Sierra Nevada of Grenada. This peak, according to the geodesical measurement of Don Clemente Roxas, is 1824 toises of absolute height, whilst Mount Perdu, in the Pyrenees, is only 1763 toises. Near the Mulahacen is situate the Pico de Veleta, which is 1781 toises.

I was presented to the court of Aranjuez in March, 1799. The king received me graciously. I explained to him the motives, which led me to undertake a voyage to the new continent, and the Philippine islands, and I presented a memoir on this subject to the secretary of state. Mr. d'Urquijo supported my demand, and overcame every obstacle. The conduct of this minister was so much the more generous, as I had no personal connection with him, and the zeal which he constantly showed for the execution of my projects had no other motive than his love for the sciences. I feel that it is no less a duty than a pleasure, to record in this work the services which he rendered me.

I obtained two passports, one from the first secretary of state, the other from the council of the Indies. Never had so extensive a permission been granted to any traveller, and never had any foreigner been honoured with more confidence on the part of the Spanish government. To dissipate every doubt, which the viceroys or captains general, representing the royal authority in America, might entertain with respect to the nature of my labors, the passport of the *primera secretaria de estado* stated, that I was authorised to make free use of my instruments of physic and geodesy, that I might make astronomical observations through the whole of the Spanish dominions, measure the height of mountains, examine the productions of the soil,

and execute all operations which I should judge useful for the progress of the sciences*. These orders of the court were strictly followed, even after the events which obliged Mr. d'Urquijo to quit the ministry. I endeavoured on my part to justify by my conduct these marks of unceasing attention. During my abode in America, I presented the governors of the Provinces with a duplicate of the materials which I had collected, and which might interest the mother country by throwing some light on the geography and the statistics of the colonies. Agreeably to the offer I had made before my departure, I addressed several geological collections to the cabinet of natural history of Madrid. The purpose of our journey being merely scientific, we succeeded in conciliating the friendship of the natives, and that of the Europeans entrusted with the administration

* Ordena S. M. a los Capitanes generales, comandantes, gobernadores, yntendentes, corregidores y demas justicias no impidan por ningun motivo la conduccion de los instrumentos de fisica, quimica, astronomia y matematicas, ni el hacer en todas las posessiones ultramarinas las observaciones y experimentos que juzgue utiles, como tampoco el colectar libremente plantas, animales, semillas y minerales, medir la altura de los montes, examinar la naturaleza de estos y hacer observaciones astronomicas y descubrimentos utiles para el progresso de las ciencias: pues por el contrario quiere el Rey que todas las personas a quienes corresponda, den al B. de Humboldt todo el favor, auxilio y proteccion que necessite. (De Aranjuez, 7 de mayo 1799.)

of these vast countries. During the five years that we travelled throughout the new continent, we did not perceive the slightest mark of mistrust; and we remember with pleasure, that amidst the most painful privations, and whilst we were struggling against the obstacles which arose from the savage state of those regions, we never had to complain of the injustice of men.

Many considerations might have induced us to prolong our abode in Spain. The Abbe Cavanilles, no less remarkable for the variety of his attainments than his acute intelligence, Mr. Nee, who, together with Mr. Hænke, had, as botanist, made part of the expedition of Malaspina, and who had formed one of the greatest herbals that was ever seen in Europe; Don Casimir Ortega, the Abbe Pourret, and the learned authors of the Flora of Peru, Messrs. Ruiz and Pavon, opened to us without restriction their rich collections. We examined part of the plants of Mexico, discovered by Messrs. Sesse, Mocino and Cervantes, whose drawings had been sent to the Museum of Natural History of Madrid. This great establishment, the direction of which was confided to Mr. Clavijo, author of an elegant translation of the works of Buffon, offered us, it is true, no geological *suite* of the Cordilleras, but Mr. Proust, so well known by the great accuracy of his chemical labors, and a distinguished mineralogist, Mr. Hergen, gave us curious details on several mineral sub-

stances of America. It would have been useful to us, to have employed a longer time in studying the productions of the countries, which were to be the objects of our researches, but our impatience to take advantage of the permission given us by the court was too great, to suffer us to delay our departure. For a year past, I had experienced so many disappointments, that I could scarcely persuade myself, that my most ardent wishes would be at length fulfilled.

We left Madrid about the middle of May, crossed a part of Old Castile, the kingdoms of Leon and Galicia, and reached Corunna, whence we were to embark for the Island of Cuba. The winter having been long and tempestuous, we enjoyed during the journey that mild temperature of the spring, which in so southern a latitude is commonly that of March and April. The snow still covered the lofty granitic tops of the Guadarama; but in the deep vallies of Gallicia, which resemble the most picturesque spots of Switzerland and the Tyrol, cistuses loaded with flowers and aborescent heaths clothed every rock. We quitted without regret the elevated plain of the two Castiles, which is every where deprived of vegetation, and where the severity of the winter's cold is followed by the overwhelming heat of summer. From the few observations I personally made, the interior of Spain forms a vast plain, which, elevated three hundred toises (five hundred and eighty-four

metres) above the level of the ocean, is covered with secondary formations, grit stone, gypsum, salgem, and the calcareous stone of Jura. The climate of the Castiles is much colder than that of Toulon and Genoa; for its mean temperature scarcely rises to 15° of the centigrade thermometer*.

We are astonished to find, that in the latitude of Calabria, Thessaly, and Asia Minor, the orange-trees do not flourish in the open air †. The central elevated plain is encircled by a low and narrow zone, where the chamærops, the date-tree, the sugar cane, the banana, and a number of plants common to Spain and the north of Africa, vegetate on several spots, without suffering from the rigors of winter. From the 36th to the 40th degrees of latitude, the medium temperature of the year is from 17 to 20 degrees; and by a concurrence of circumstances, which it would be too long to explain, this happy region is become the principal seat of industry and intellectual improvement.

* Whenever in the course of this work, the contrary is not expressly indicated, the variations of the temperature are noted after the centigrade scale of the thermometer with mercury; but to avoid the errors which may arise from the reductions of the different scales, and the frequent suppression of decimal fractions, I have printed the partial observations, such as the instrument I made use of gave me. On this point I have followed the plan adopted by the illustrious author of the *Basis of the Metrical System*, *M. Delambre*.

† For the note see the following page.

† As in the course of this historical narrative, the influence of the medium temperature in the unfolding of vegetation and the productions of agriculture is often mentioned, it will be proper to give in this place the following data, founded on exact observations, and adapted to serve as terms of comparison. I have added an asterisk to the names of cities, the climate of which is singularly modified, either by their elevation above the level of the ocean, or by the circumstances independant of the latitude.

Umeo	Lat. 63° 50′	Mean Temp. 0·7°		(Næzen and Buch).
Petersburgh	59° 56′	3·8°		(Euler). Very eastern position.
Upsal	59° 51′	5·5°		(Buch).
Stockholm	59° 20′	5·7°		(Wargentin).
Copenhagen	55° 41′	7·6°		(Bugge).
Berlin	52° 31′	8·1°		
Paris	48° 50′	10·7°		(Bouvard), average of 7 years.
Geneva*	46° 12′	10 1°		Height, 396 metres.
Marseilles	43° 17′	14·3°		Saint Jacques.
Toulon*	43° 3′	17·5°		Mountains to the north.
Rome	41° 53′	15·7°		(William de Humboldt).
Naples	40° 50′	18·0°		
Madrid*	40° 25′	15·0°		Height, 603 metres.
Mexico*	19° 25′	17·0°		Height, 2277 metres.
Vera Cruz*	19° 11′	25·4°		Dry sandy coast.
Equator at the level of the Ocean	0° 0′	27·0°		
Quito	0° 14′	15·0°		Height, 2908 metres.

This table differs slightly from that I gave in the introduction to Thomson's Chemistry, Vol. i, p. 99 (French translation) and which was not formed from observations equally exact.

Ascending from the shores of the Mediterranean into the kingdom of Valencia, towards the lofty plains of La Mancha and the Castiles, we seem to recognize far inland, from the lengthened declivities, the ancient coast of the Peninsula. This curious phenomenon recalls the traditions of the Samothracians, and other historical testimonies, according to which it is supposed, that the eruption of the waters through the Dardanelles, augmenting the basin of the Mediterranean, rent and overflowed the southern part of Europe. If we admit that these traditions owe their origin, not to mere geological reveries, but to the remembrance of some ancient catastrophe, we see the central elevated plain of Spain resisting the efforts of these great inundations, till the draining of the waters, by the straights formed between the pillars of Hercules, brought the Mediterranean progressively to its present level, while lower Egypt emerged above its surface on the one side, and the fertile plains of Tarragon, Valencia, and Murcia, on the other. Every thing that relates to the formation of this sea*, which has had so powerful an influence

* Diodor. Sicul. edit. Wesseling. Amstelodam., 1746, Lib. IV, c. 18, p. 336; Lib. V, c. 47, p. 369. Dionys. Halicarn. ed. Oxon. 1704, Lib. I, c. 61, p. 49. Aristot. Opp. omn. ed. Casaub. Lugdun. 1590. Meteorolog. Lib I, c. 14, t. I, p. 336. H. Strabo, Geogr. ed. Thomas Falconer. Oxon. 1807, t. I, p. 76 et 83. (Tournefort, Voyage au Levant, p. 124. Pallas, Voyage en Russie, t. V, p. 195. Choiseul-Gouffier, Voyage pittoresque, t. II, p. 116. Dureau de la Malle, Géographie physique de la mer Noire, p. 157, 196, et

on the first civilization of mankind, is highly interesting. We might suppose, that Spain, forming a promontory amidst the waves, was indebted for its preservation to the height of its land; but in order to give weight to these systematic ideas, we must clear up the doubts that have arisen respecting the rupture of so many transverse dikes; we must discuss the probability of the Mediterranean having been formerly divided into several separate basins, of which Sicily and the Isle of Crete appear to mark the ancient limits. We will not here risk the solution of these problems, but will satisfy ourselves in fixing the attention on the striking contrast in the configuration of the land in the eastern and western extremities of Europe. Between the Baltic

341. Olivier, Voyage en Perse, t. III, p. 130. Meiners über die Verschiedenheiten der Menschennaturen, p. 118.) Some of the ancient geographers, such as Straton, Eratosthenes, and Strabo, believed, that the Mediterranean, swelled by the waters of the Euxine, the Palus Meotis, the Caspian sea, and the lake Aral, had broken the pillars of Hercules; others, such as Pomponius Mela, admitted, that the irruption was made by the waters of the ocean. In the first of these hypotheses, the height of the land between the Black Sea and the Baltic, and between the ports of Cette and Bourdeaux, determine the limit, which the accumulation of the waters may have reached before the junction of the Black sea, the Mediterranean, and the Ocean, as well to the north of the Dardanelles, as to the east of this strip of land, which formerly joined Europe to Mauritania, and of which in the time of Strabo certain vestiges remained in the Islands of Juno and the Moon.

and the Black Sea, the ground is at present scarcely fifty toises above the level of the ocean, while the plain of La Mancha, if placed between the sources of the Niemen and the Borysthenes, would figure as a group of mountains of considerable height. If the causes, which may have changed the surface of our planet, be an interesting speculation, investigations of the phenomena, such as they offer themselves to the measures and observations of the naturalist, lead to far greater certainty.

From Astorga to Corunna, especially from Lugo, the mountains rise gradually. The secondary formations gently disappear, and are succeeded by the transition rocks, which indicate the proximity of primitive strata. We found considerable mountains composed of that ancient gray stone, which the mineralogists of the school of Freibourg name *grauwakke,* and *grauwakkenschiefer.* I do not know whether this formation, which is not frequent in the south of Europe, has hitherto been discovered in other parts of Spain. Angular fragments of lydian stone, scattered along the vallies, seemed to indicate, that the transition schist is the basis of the strata of grauwakke. Near Corunna even granitic ridges stretch as far as Cape Ortegal. These granites, which seem formerly to have been contiguous to those of Britanny and Cornwall, are perhaps the wrecks of a chain of mountains destroyed and sunk in the waves. Large and beautiful crystals of feldspath characterize this

rock; the common tin ore is sometimes discovered there, the working of which is a laborious and unprofitable operation for the inhabitants of Gallicia.

When we reached Corunna, we found the port blockaded by an English man of war and two frigates, which were stationed to intercept the communication between the mother-country and the American colonies; since it was from Corunna, and not from Cadiz, that a packet boat *(correo maritimo)* sailed every month for the Havannah, and another every two months for Buenos Ayres, or the mouth of the river Plata. I shall in the course of my work give an exact statement of the posts on the new continent; and shall here only observe, that since the administration of Count Florida Blanca, the service of the land post office has been so well organized, that an inhabitant of Paraguay, or of the province of Jaen de Bracamoros *, may carry on a regular correspondence with New Mexico, or the coasts of California, at a distance equal to that from Paris to Siam, or from Vienna to the Cape of Good Hope. In the same manner, a letter confided to the post in a small town of Aragon arrives at Chili, or in the missions of the Oronoco, provided the name of the corregimento, or district that comprises the Indian village to which the letter is addressed, be distinctly marked. It is pleasing to recall to mind institu-

* On the banks of the river of Amazons.

tions, which may be considered as among the greatest benefits of modern civilization. The establishment of maritime and inland posts has placed the colonies in more intimate intercourse with each other, and with the mother-country. The circulation of ideas is become more expeditious; the complaints of the natives reach Europe with more facility, and the supreme authority has sometimes succeeded in repressing vexations, which, from the distance of the place, would have remained for ever unknown.

The first secretary of state had recommended us very particularly to the brigadier D. [illegible]el Clavijo, who had lately been named director-general of the maritime posts. This officer, distinguished for his talent in ship-building, was employed in forming new dock-yards at Corunna. He neglected nothing to render our abode at this port agreeable, and advised us to embark on board the sloop Pizarro*, which was to sail in company with the Alcudia, the packet-boat of the month of May, which, on account of the blockade, had been detained three weeks in the port. The Pizarro was not esteemed a swift sailer; but she had happily escaped the English vessels in her long voyage from the river Plata to Corunna. Mr. Clavijo ordered the necessary arrangements to be made on board the sloop for placing our instruments, and

* According to the Spanish nomenclature, the Pizarro was a light frigate (*fragata lijera*).

facilitating the means of making chemical experiments on the air, during our passage. The captain of the Pizarro received orders to stop at Teneriff, as long as we should judge necessary, to visit the port of Orotava, and ascend the peak.

We had yet ten days to wait before we embarked, which seemed to us a long delay. During this interval, we employed ourselves in preparing the plants we had collected in the beautiful valies of Gallicia, which no naturalist had yet visited: we examined the fuci and the molluscæ which the north west winds had cast with great profusion at the foot of the steep rock, on which the light-house of the tower of Hercules is built. This edifice, called also the Iron Tower, was repaired in 1788. It is ninety-two feet high, its walls are four feet and a half thick, and its construction clearly proves, that it was built by the Romans. An inscription discovered near its foundations, a copy of which M. Laborde obligingly gave me, informs us, that this pharos was constructed by Caius Sevius Lupus, architect of the city of Aqua Flavia (Chaves), and that it was dedicated to Mars. Why is the Iron Tower called in the country by the name of Hercules? Was it built by the Romans on the ruins of a Greek, or Phœnician edifice? Strabo, indeed, affirms, that Gallicia, the country of the Callæci, had been peopled by Greek colonies. According to an extract from the geography of Spain, by Asclepiades the Myrlæan, an ancient tradition

stated, that the companions of Hercules had settled in these countries *.

I made the necessary observations to assure myself of the rate of going of Lewis Berthoud's time-keeper, and I had the satisfaction to find, that it had not changed its diurnal retardation, notwithstanding the shocks it had met with in our journey from Madrid to Corunna. This circumstance was the more important, as much uncertainty existed respecting the true longitude of Ferrol, the centre of which town is 10′ 20″ east of the tower of Hercules at Corunna. An occultation of Aldebaran, and a long series of eclipses of Jupiter's satellites, observed by Admiral Mazarredo, and calculated by Mechain, seemed to prove that, in the maritime atlas of Tofino, which is in other respects so accurate in the indication of partial distances, the determinate positions of Corunna and Ferrol were inexact by two or three leagues. My time-keeper confirmed these doubts respecting the operations of Tofino. I found †

* Strabo, ed. Casaub. Lutet. Par. 1620, Lib. III, p. 157. The Phœnicians and Greeks visited the coasts of Gallicia (Gallæcia) to trade for tin, which they drew from this country, as well as from the Cassiterides. *Strabo*, Lib. III, p. 147. *Plin.* Lib. XXXIV, c. 16.

† Observat. Astron. Introd. p. xxxvi, t. I, p. 24 et 33. Espinosa, Memorias sobre las observaciones astron. hechas por los navegantes espanoles, 1809, t. i, p. 23. If we suppose, that my chronometer did not augment its diurnal retardation during the passage from Madrid to Corunna, which

the observatory of the Admiralty at Ferrol $0^h\ 42'\ 21''$ west of Paris. The mean of all the observations made by the Spanish astronomers, and lately published by Mr. Espinosa, gives $0^h\ 42'\ 2{\cdot}5''$. I have already observed, that several expeditions having set sail from this last port, the false position, which has been laid down, has had a disadvantageous influence on the longitudes of several towns of America, determined not by absolute observations, but only by the difference of time. Although time-keepers extend the limits of our geographical knowledge, they often contribute to propagate the mistake in the longitude of the point of departure, because they render the position of the coast in the most distant regions dependent on this single point.

The ports of Ferrol and Corunna communicate with the same bay, so that a vessel driven by bad weather towards the coast may anchor in either according to the wind. This advantage is invaluable, where the sea is almost always tempestuous, as between the Capes Ortegal and Finisterre, which are the promontories Trileucum and Artabrum* of the ancient geography. A narrow passage, flanked by perpendicular rocks

would be contrary to direct experiments made at Marseilles, the longitude of Ferrol will still be $23''$ of time more than that at which it is fixed by Mr. Tofino.

* Ptolemy cites the port of the Artabri: *Geogr.* Lib. II. cap. 6. (*Bertii Theatr. geograph. vet. Amstel.*, 1618, p. 34.)

of granite, leads to the extensive basin of Ferrol. No port in Europe has so extraordinary an anchorage, from its very inland position. The narrow and tortuous passage, by which vessels enter this port, has been opened, either by the irruption of the waves, or by the reiterated shocks of very violent earthquakes. In the New World, on the coasts of new Andalusia, the Laguna del Obispo, (Bishop's lake) is formed exactly like the port of Ferrol. The most curious geological phenomena are often repeated at immense distances on the surface of continents; and the naturalists, who have examined different parts of the globe, are struck with the extreme resemblance observed in the rents on coasts, in the sinuosities of the vallies, in the aspect of the mountains, and in their distribution by groups. The accidental concurrence of the same causes must have every where produced the same effects; and amidst the variety of nature, an analogy of structure and form is observed in the arrangement of brute matter, as well as in the internal organization of plants and of animals.

Crossing from Corunna to Ferrol, in shallow water, near the White Signal, in the bay, which according to d'Anville is the Portus Magnus of the Ancients, we made several experiments by means of a valved thermometrical sounding lead, on the temperature of the ocean, and on the decrement of caloric in the successive strata of water. The

thermometer on the bank, and near the surface, was from 12·5° to 13·3° centigrades, while in deep water it constantly marked 15° or 15·3°, the air being at 12·8°. The celebrated Franklin, and Mr. Jonathan Williams, author of the work which appeared at Philadelphia under the title of Thermometrical Navigation, were the first to invite the attention of naturalists to the phænomena of the temperature of the ocean over shoals, and in that zone of tepid and flowing waters, which runs from the Gulf of Mexico to the Banks of Newfoundland, and the northern coasts of Europe. The observation, that the proximity of a sand-bank is indicated by a rapid descent of the temperature of the sea at its surface, is not only interesting to the naturalist, but may become also very important for the safety of navigators. The use of the thermometer ought certainly not to lead us to neglect the use of the lead; but the experiments, which I shall mention in the course of this narrative, sufficiently prove, that variations of temperature, sensible to the most imperfect instruments, indicate danger long before the vessel reaches the shoals. In such cases, the frigidity of the water may engage the pilot to heave the lead in places, where he thought himself in the most perfect safety. We shall examine in another place the natural causes of these complicated phænomena; and shall only here observe, that the waters which cover the shoals owe in a great

measure the diminution of their temperature to their mixture with the lower strata of water, which rise towards the surface on the edge of the banks.

A heavy sea from the North-west hindered us from continuing our experiments on the temperature of the ocean in the bay of Ferrol. The great height of the waves was the effect of an impetuous wind at sea, and forced the English vessels to retire from the coast. Desirous to avail ourselves of this opportunity of sailing, we instantly embarked our instruments, books, and baggage; but the west wind, which blew still more impetuously, did not permit us to weigh anchor, and during this delay we wrote to our friends in France and Germany. The moment of leaving Europe for the first time is attended with a solemn feeling. We in vain summon to our minds the frequency of the communication between the two worlds; we in vain reflect on the great facility, with which, from the improved state of navigation, we traverse the Atlantic, which compared to the great ocean is but a larger arm of the sea; the sentiment we feel when we first undertake so distant a voyage is not the less accompanied by a deep emotion, unlike any other impression we have hitherto felt. Separated from the objects of our dearest affections, entering in some sort on a new state of existence, we are forced to turn back on the family of our thoughts, and we find them

in a situation which they have never known before. Among the letters which I wrote at the time of our embarking, one had a considerable influence on the direction of our travels, and on our succeeding operations. When I left Paris with the intention of visiting the coasts of Spain, the expedition for discoveries in the Southern Ocean seemed to be adjourned for several years. I had agreed with Captain Baudin, that if, contrary to his expectation, his voyage took place at an earlier period, and the news should reach me in time, I would endeavour to return from Algiers to a port in France, or Spain, to join the expedition. I renewed this promise on leaving Europe, and wrote to M. Baudin, that if the government persisted in sending him by Cape Horn, I would endeavour to meet him, either at Monte Video, Chili, or Lima, or wherever he should touch in the Spanish Colonies. In consequence of this engagement, I changed the plan of my journey, on reading in the American papers, in 1801, that the French expedition had sailed from the port of Havre, to make the tour of the globe from east to west. I hired a small vessel from Batabano, in the Island of Cuba, to Portobello, and thence crossed the isthmus to the coasts of the southern ocean; this mistake of a journalist led M. Bonpland and myself to travel eight hundred leagues through a country we had no intention to visit. It was only at Quito, that a letter from M.

Delambre, perpetual secretary of the first class of the institute, informed us, that Captain Baudin went by the Cape of Good Hope, without touching on the eastern or western coasts of America.

I cannot recal without regret an expedition, which is connected with several events of my life, and the history of which has lately been sketched by a * man of science, no less distinguished for the number of his discoveries, than by the noble courage which he displayed in circumstances of extreme difficulty and danger.

When I went into Spain I could not carry with me the complete collection of my physical, geodesical, and astronomical instruments. I had left the duplicates at Marseilles, with the intention of ordering them to be sent to Tunis or Algiers, when I should find an opportunity of passing over to the coasts of Barbary. In peaceable times travellers ought by no means to carry with them the complete collection of their instruments: they should on the contrary cause them to be sent successively, in order to replace such as suffer most by use and carriage. This precaution is particularly necessary, when they are obliged to determine a great number of points by means merely chronometrical. But in times of maritime

* Mr. Peron, lost to the sciences at thirty five years of age, after a long and painful illness. See an interesting memoir on the life of this traveller, by Mr. Deleuze, in his Annales du Museum, t. 17.

warfare, it is highly prudent never to lose sight either of instruments, manuscripts, or collections. Sad experience, as I have observed in the introduction to this work, has confirmed the justness of this observation. Our abode at Madrid and Corunna had been too short, to transport from Marseilles the meteorological apparatus I had left.

It was in vain that I requested its being sent to the Havannah, after our return from the Orinoco; neither the apparatus nor the achromatic telescopes, nor the timekeeper by Arnold, which I had sent for to London, reached America. The following is the list of the instruments I had collected for my journey from the year 1797, and which, excepting a small number easy to replace, served me till 1804

LIST OF THE PHYSICAL AND ASTRONOMICAL INSTRUMENTS.

A *timekeeper by Lewis Berthoud, No.* 27. This timekeeper had belonged to the celebrated Borda. I have published the detail of its rate of going, in the introduction to my collection of astronomical observations;

A *demi-chronometer by Seyffert*, serving for ascertaining the longitude at short distances;

A *three-foot achromatic telescope by Dollond*, intended for the observation of Jupiter's satellites;

A *telescope by Caroché*, of less dimensions, with an apparatus to fix the instrument to the trunk of a tree, in forests;

A *lunette d'epreuve*, with a micrometer engraved on glass, by M. Köhler, astronomer at Dresden. This apparatus, placed on the plane of the artificial horizon, serves to level bases, to measure the progress of an eclipse of the sun or the moon, and determine the value of very small angles under which very remote mountains appear;

A *sextant by Ramsden*, of ten inches radius, with a silver limb, and telescopes which magnify from twelve to sixteen times;

A *snuffbox sextant by Troughton*, of two inches radius, with a nonius divided into minutes, telescopes which magnify four times, and an artificial horizon of crystal. This small instrument is very useful for travellers when forced in a boat to lay down the sinuosities of a river, or take angles on horseback without dismounting;

A *reflecting and repeating circle by Le Noir*, of twelve inches diameter, with a mirror of platina*;

A *theodolite by Hurter*, the azimuth circle of which was eight inches in diameter;

An *artificial horizon by Caroché*, of plane glass,

* I have compared in another place the advantages and disadvantages, in long journeys, of the reflecting instruments and astronomical *repeating circles*. (*Astron. Observ. Introd.* t. I, p. 17.)

six inches in diameter, with an air bubble level, the divisions of which are equivalent to two sexagesimal seconds ;

A *quadrant by Bird*, with a radius of a foot, furnished with a double division of the limb into ninety and ninety-six degrees, the micrometer screw indicating two sexagesimal seconds; the perpendicularity of the plane capable of being determined by means of a plummet and a large air-bubble level ;

A *graphometer by Ramsden*, placed on a cane, with a magnetic needle, and a wire meridian to take magnetical azimuths ;

A *dipping needle* of twelve inches, constructed on the principles of Borda and Le Noir. This instrument, of the most perfect execution, was ceded to me, at the time of my departure, by the French board of longitude. The figure of this instrument will be found in the narrative of the voyage of d'Entrecasteaux*, the astronomical part of which was composed by a learned navigator, M. de Rossel. An azimuth circle serves to find the plane of the magnetic meridian, either by correspondent dips, or by seeking the position in which the needle is vertical, or observing the minimum of the dippings. The instrument is verified by ob-

* Vol. ii, p. 14.

serving on the east and west side, and changing the poles:

A *variation compass by Le Noir*, constructed on the principles of Lambert, and furnished with a wire meridian. The nonius was divided at every two minutes;

A *needle* twelve inches long, furnished with *sight-vanes*, and suspended to an untwisted thread according to the method of Coulomb. This apparatus, like the *magnetic telescope of Prony*, served me to determine the small horary variations of the magnetic variation, and the intensity of the forces which change with the latitudes. The oscillations of the great magnetic dipping needle of M. Le Noir give also a very exact measure of this last phenomenon.

A *magnetometer of Saussure* *, constructed by M. Paul at Geneva, with a limb that corresponds to an arch of three feet radius;

An *invariable pendulum*, constructed by Mr. Megnie, at Madrid;

Two *barometers by Ramsden;*

Two *barometrical apparatuses* †, with the aid of which we find the mean height of the barometer,

* This magnetometer, which I found inaccurate, the theodolite, and reflecting circle, are the only instruments which I could not embark with me at Corunna.

† I have described this apparatus in the Journal de Physique, t. xlvii, p. 468, and in my Observ. Astron. t. i, p. 366.

by successively plunging into a vessel several glass tubes, filled with mercury, closed at one end by a steel screw, and placed in a metal case;

Several *thermometers by Paul, Ramsden, Megnie, and Fortin;*

Two *hygrometers of Saussure and Deluc,* of hair and whalebone;

Two *electrometers of Bennet and Saussure,* of gold leaf and elder pith, furnished with conductors four feet long, to collect, according to the method prescribed by Mr. Volta, the electricity of the atmosphere, by means of an ignited substance which yields smoke;

A *cyanometer by Paul.* To give me the means of comparing with some certainty the blue colour of the sky, as it is seen on the summit of the Alps and the Cordilleras, M. Pictet had this cyanometer colored conformably to the division of that which M. de Saussure made use of at the top of Mount Blanc, and during his memorable abode at the Col du Geant;

An *eudiometer of Fontana,* for nitrous gas; without strictly knowing how many parts of this gas are necessary to saturate a portion of oxygen, we may still precisely determine the quantity of atmospheric azote, and consequently the purity of the air, by employing, beside the nitrous gas, the oxygenated muriatic acid, or a solution of sulphat of iron. Volta's eudiometer,

though the most exact of any, is embarrassing for travellers, who traverse damp countries, on account of the small electric discharge, which the inflammation of oxygen and hydrogen gasses requires. The most portable eudiometrical apparatus, the most speedy and most eligible in every respect, is that published by M. Gay-Lussac in the memoirs of the society of Arcueil*;

A *phosphoric eudiometer by Reboul.* By the nice researches of Mr. Thenard, on charcoal mixed with phosphorus, it is proved, that the slow action of this acidifiable basis † yields results less exact than strong combustion;

An *apparatus by Paul,* proper to determine with the greatest precision the *degree* at which water boils at different heights, above the level of the ocean. The thermometer with a double nonius had been constructed from the apparatus, which M. de Saussure employed in his excursions;

A *thermometrical lead by Dumotier,* consisting of a cylindric vase, furnished with two conical valves, and enclosing a thermometer;

Two *areometers of Nicholson and Dollond;*

A *compound microscope of Hofmann,* described in

* Vol. 2, p. 235. See also the memoirs in the composition of the air which I published conjointly with Mr. Gay-Lussac in the Journal de Physique, vol. lix, p. 129, and my Zoological Observations, vol. i, p. 256.

† Bulletin of the Philomathic Society, 1812, No 37, p. 93.

the history of the Cryptogamiæ by Mr. Hedwig; a *standard metre* by Le Noir, *a land surveyor's chain;* an *assay-balance;* a *rain gauge; tubes of absorption* to indicate small quantities of carbonic acid and oxygen, by means of lime-water, or a solution of sulphuret of potash; some *Haüy's electroscopical apparatuses;* vases to measure the quantity of the *evaporation* of liquids in the open air; a mercurial *artificial horizon;* small *Leyden phials* to be charged by rubbing; *galvanic apparatus; reagents* to try some experiments on the chemical composition of mineral waters, and a great number of small tools necessary for travellers to repair such instruments as might be deranged from the frequent falls of the beasts of burden.

We spent two days at Corunna, after our instruments were embarked. A thick fog, which covered the horizon, at length indicated the change of weather we so anxiously desired. On the 4th of June, in the evening, the wind turned to the north east, a point, which, on the coast of Gallicia, is considered very constant during the summer. The Pizarro prepared to sail on the 5th, though we had intelligence but a few hours before, that an English squadron had been hailed from the watch tower of Sisarga, appearing to stand towards the mouth of the Tagus. Those who saw our ship weigh anchor, asserted that we should be captured in three days,

and that, forced to follow the fate of the vessel, we should be carried to Lisbon. This prognostic gave us the more uneasiness, as we had known some Mexicans at Madrid, who, in order to return to Vera-Cruz, had embarked three times at Cadiz, and who, having been each time taken at the entrance of the port, were obliged to return to Spain through Portugal.

The Pizarro set sail at two in the afternoon. As the long and narrow passage by which a ship sails from the port of Corunna opens towards the north, and the wind was contrary, we made eight short tacks, three of which were useless. A fresh tack was made, but very slowly, and we were for some moments in danger at the foot of the fort St. Amarro; the current having driven us very near the rock, on which the sea breaks with considerable violence. We remained with our eyes fixed on the castle of St. Antony, where the unfortunate Malaspina * was then a captive in a state prison. On the point of leaving Europe to visit the countries which this illustrious traveller had visited with so much advantage, I could have wished to have fixed my thoughts on some object less affecting.

At half past six we passed the tower of Hercules, which is the lighthouse of Corunna, as we have already mentioned, and where, from the

* Essai Politique sur le Mexique, t. I, p. 338. Observ. Astron. t. I, p. 34.

remotest times, a coal fire is kept up for the direction of vessels. The light of this fire is no way proportionate to the beautiful construction of so vast an edifice; being so weak, that the ships cannot perceive it till they are in danger of striking on the shore. Towards the close of day, the wind increased, and the sea ran high. We directed our course to the north west, in order to avoid the English frigates, which we supposed were cruizing off those coasts. About nine we spied the light of a fishing hut, at Sisarga, which was the last object we beheld in the west of Europe. As we advanced, this feeble light mingled itself with the stars, which rose on the horizon; and our eyes remained involuntarily fixed on this object. Such impressions are not easily effaced from the memory of those who have undertaken long voyages, at an age when the emotions of the heart are in full vigour. How many remembrances are awakened in the imagination by a luminous point, which in the midst of an obscure night, appearing at intervals above the swelling waves, points out the coast of our native home!

We were obliged to run under our courses, at the rate of ten knots, though the vessel was not constructed for making such way. At six in the morning the ship rolled so much, that the fore-top gallant mast was carried away, but without any disagreeable consequence. As we were thirteen days in our passage from Corunna to the Canary

Islands, it was long enough to expose us to the danger of meeting English vessels, on stations so much frequented as the coasts of Portugal. No sail however appeared in sight the first three days, which gave encouragement to the crew, who were no way prepared for fighting.

On the 7th we were in the latitude of Cape Finisterre. The group of granitic rocks, which forms part of this promontory, like that of Torianes and Mont de Corcubion, bears the name of the Sierra de Toriñona. Cape Finisterre is lower than the neighbouring lands; but the Toriñona is visible at sea at 17 leagues distance, which proves that the elevation of its highest summit is not less than 300 toises (582 metres). The spanish navigators pretend, that on these coasts the magnetic variation differs extremely from that observed at sea. M. Bory*, it is true, in the voyage of the sloop Amaranth, found, in 1751, that the variation of the needle, determined at the Cape, was four degrees less than could have been conjectured from the observations made at the same period, along the coasts. In the same manner as the granite of Gallicia contains tin disseminated in its mass, that of Cape Finisterre probably contains micaceous iron. In the mountains of the Upper Palatinate, there are indeed granitic rocks, in

* Mémoires de L'Académie des Sciences, 1768, p. 280. Fleurieu, Voyage de l'Isis, t. i, p. 225.

which crystals of micaceous iron take the place of common mica.

The 8th, at sunset, we descried from the mast-head an English convoy, which sailed along the coast, steering towards the south east. In order to avoid it, we altered our course during the night. From this moment no light was permitted in the great cabin, to prevent our being seen at a distance. This precaution, used on board all merchant vessels, and prescribed in the regulations of the packet-boats of the royal navy, was extremely irksome to us during the passages we made in the course of the five following years. We were constantly obliged to make use of dark-lanterns to examine the temperature of the water, or read the divisions on the limb of the astronomical instruments. In the torrid zone, where twilight lasts but a few minutes, our operations ceased almost at six in the evening. This state of things was so much the more displeasing to me, as from the nature of my constitution I never was subject to sea-sickness, and feel an extreme ardour for study during the whole time I am at sea.

A voyage from the coast of Spain to the Canary Islands, and thence to South America, is scarcely attended with any event which deserves attention, especially when undertaken in summer. The navigation is often less dangerous than crossing one of the great lakes of Switzerland, I shall therefore confine myself in this

narrative to the general results of the magnetic and metereological experiments, which I made in this part of the ocean; and offer some observations, which may prove interesting to navigators. Whatever relates to the variations of the temperature of the air, and that of the sea, the hygrometrical state of the atmosphere, the blue colour of the sky, the inclination and intensity of the magnetic focus, will be found collected in my journal at the end of the third chapter, where it will be seen, from the detail and number of experiments, that we endeavoured to make the best use possible of the instruments with which we were furnished. It were to be wished, that the same observations could be repeated in the African and Asiatic seas, to indicate exactly the constitution of the atmosphere which covers the great basin of the waters.

The 9th of June, latitude 39° 50′, and longitude 16° 10′ west of the meridian of the observatory of Paris, we began to feel the effects of the great current, which from the Azores directs itself towards the straits of Gibraltar, and the Canary Islands. Comparing the place of our ship deduced from Berthoud's time-keeper with the pilot's reckoning, I was able to discover the smallest variations in the direction and velocity of the currents. From 37° to 30° of latitude, the vessel was sometimes, carried in twenty-four hours, from eighteen to twenty-six miles to the east. The direction of the current was at first E by S, but nearer the

straits it became due east. Captain Mackintosh, and one of the most distinguished navigators of our time, Sir Erasmus Gower, have noticed the modifications of this movement of the waters at different seasons of the year. Several pilots who frequent the Canary Islands have found themselves on the coasts of Lancerotte, when they expected to make good their landing on the Isle of Teneriff. M. de Bougainville*, in his passage from Cape Finisterre to the Canary Islands, found himself in sight of the Isle of Ferro, 4° more to the east than his reckoning indicated.

The current which is felt between the Azores, the southern coasts of Portugal, and the Canary Islands, is commonly attributed to that tendency towards the east, which the straits of Gibraltar impress on the waters of the Atlantic Ocean. M. de Fleurieu, in notes added to the voyage of Captain Marchant†, observes even, that the Mediterranean, losing, by evaporation, more water than the rivers can supply, causes a movement in the neighbouring ocean, and that the influence of the Straits is felt at the distance of six hundred leagues. Without derogating from the sentiments of esteem which I owe to this celebrated navigator, from whose works I have derived much instruction, I may be permitted to consider this important object in a far more general point of view.

* Voyage round the World, vol. i, p. 10.

† Vol. ii, p. 9 and 229.

When we cast our eyes over the Atlantic, or that deep valley which divides the western coasts of Europe and Africa from the eastern coasts of the new continent, we distinguish a contrary direction in the motion of the waters. Between the tropics, especially from the coasts of Senegal to the Caribbean sea, the general current, that which was earliest known to mariners, flows constantly from east to west. This is called the Equinoctial current. Its mean rapidity, corresponding to different latitudes, is nearly the same in the Atlantic and in the Southern Ocean*, and may be estimated at nine or ten miles in twenty-four hours, consequently from 0·59 to 0·65 of a foot every second! In those latitudes the waters run towards the west, with a velocity equal to a fourth of the rapidity of the greater part of the large rivers of Europe. The movement of the ocean, in a direction contrary to that of the rotation of the globe, is probably connected with this last phænomenon, only as far as the rotation changes the polar winds, which, in the low regions of the atmosphere, bring back the cold air of the high latitudes towards the equator, into

* In comparing the observations which I had occasion to make in the two hemispheres, with those which are laid down in the voyages of Cook, La Péyrouse, d'Entrecasteaux, Vancouver, Macartney, Krusenstern and Marchand, I found that the swiftness of the general current of the tropics, varies from 5 to 18 miles in twenty-four hours, or 0·3 to 1·2 feet each second.

trade winds*. To this general impulsion, which these trade winds give the surface of the seas, we must attribute the equinoctial current, the force and rapidity of which are not sensibly modified by the local variations of the atmosphere.

In the channel which the Atlantic has dug between Guiana and Guinea, on the meridian of 20 or 23 degrees, from the 8th or 9th to the 2d or 3d degrees of northern latitude, where the trade winds are often interrupted by the winds which blow from the south, and south-south-west, the equinoctial current is more inconstant in its direction. Towards the coasts of Africa, the vessels are drawn towards the south-east; whilst towards the Bay of All-Saints and Cape St. Augustin, the coasts of which are dreaded by navigators who are sailing towards the mouth of the Plata; the general motion of the waters is masked by a particular current, the effects of which extend from Cape St. Roche to the Isle of Trinidad; and which runs north-west with a mean velocity of a foot or a foot and a half every second.

The equinoctial current is felt, though feebly, even beyond the tropic of Cancer, in the 26th and 28th degrees of latitude. In the vast basin of

* *Halley, on the cause of the general trade winds, in the Philosoph. Trans. for the year* 1735, p. 58. Dalton, *Meteorolog. Exp. and Essays*, 1793, p. 89. Laplace, *Explan. of the System of the World*, p. 227. The limits of the trade winds were, for the first time, determined by Dampierre, in 1666.

the Atlantic, at six or seven hundred leagues from the coasts of Africa, the vessels from Europe bound to the West Indies, find their sailing accelerated before they reach the torrid zone. More to the north, under 28 and 35 degrees, between the parallels of Teneriff and Ceuta, in 46 and 48 degrees of longitude, no constant motion is observed; there, a zone of 140 leagues in breadth separates the equinoctial current, the tendency of which is towards the west, from that great mass of water which runs towards the east, and is distinguished for its extraordinary high temperature. To this mass of waters, known by the name of the Gulf-stream *, the attention of naturalists was directed in 1776 by the curious observations of Franklin, and Sir Charles Blagden. Its direction having lately become an important object of investigation among the English and American navigators, we must go farther back, to take a more general view of this phænomenon.

The equinoctial current drives the waters of the Atlantic towards the coasts inhabited by the Mosquito Indians, and towards those of Honduras. The New Continent, stretching from south to north, forms a sort of dyke to this current. The waters are carried at first to the north-west, and passing into the gulf of Mexico through

* Sir Francis Drake had already observed this extraordinary movement of the waters, but he was unacquainted with their elevated temperature.

the strait which is formed by False Cape and Cape St. Antonio, follow the bendings of the Mexican coast, from Vera Cruz to the mouth of the Rio del Norte, and thence to the mouths of the Missisippi, and the shoals to the west of the southern extremity of Florida. Having made this vast circuit to the west, the north, the east, and the south, the current takes a new direction towards the north, and throws itself with impetuosity into the Gulf of Florida. I there observed, in the month of May, 1804, in the 26th and 27th degrees of latitude, a celerity of eighty miles in twenty-four hours, or five feet every second, though at this period the north wind blew with great violence. At the end of the Gulf of Florida, in the parallel of Cape Cannaveral, the Gulf-stream, or current of Florida, runs to the north-east. Its rapidity resembles that of a torrent, and is sometimes five miles an hour. The pilot may judge, with some certainty, of the error of his reckoning, and of the proximity of his approach toward New York, Philadelphia, or Charlestown *, when he reaches the edge of the stream;

* The current of Florida flows at greater distances from the coasts of the United States, as it advances towards the north. Its position being exactly marked in the new maritime charts, the navigator finds the longitude of the vessel to half a degree, when he is on the brink of the current, where the eddy begins, if he obtain a good observation for the latitude. This method is practised by a great number of captains of merchant ships who cross from Europe to North America.

for the elevated temperature of the waters; their strong saltness, indigo-blue colour, and the shoals of sea-weed which cover the surface, as well as the heat of the surrounding atmosphere, sensible even in winter, all indicate the Gulf-stream. Its rapidity diminishes towards the north, at the same time that its breadth increases, and the waters cool. Between Cayo Biscaino and the bank of Bahama *, the breadth is only 15 leagues, whilst in the latitude of 28 degrees and a half, it is 17, and in the parallel of Charlestown, opposite Cape Henlopen, from 40 to 50 leagues. The rapidity of the current is from three to five miles an hour, where the stream is the narrowest, and is only one mile as it advances towards the north. The waters of the Mexican Gulf, forcibly drawn to the north-east, preserve their warm temperature to such a point, that at 40 and 41 degrees of latitude I found them at 22·5° (18° R.), when, out of the current, the heat of the ocean at its surface was scarcely 17·5° (14° R.). In the parallel of New York and Oporto, the temperature of the *Gulf-stream* is consequently equal to that of the seas of the Tropics in the 18th degree of latitude; as for instance, in the parallel of Porto Rico, and the islands of Cape Verd.

* *Journal of Andrew Ellicott, Commissioner of the United States, for determining the boundary on the Ohio and Mississippi*, 1803, p. 260. *Hydraulic and nautical Observations on the Atlantic Ocean, by Gov. Pownall.* (Lond. 1787.)

To the east of the port of Boston, and on the meridian of Halifax, under 41° 25′ of latitude, and 67° of longitude, the current is near 80 leagues broad. From this point it turns suddenly to the east, so that its western edge, as it bends, becomes the western limit of the running waters, skirting the extremity of the great bank of Newfoundland, which Mr. Volney ingeniously calls the bar of the mouth of this enormous sea river *. The cold waters of this bank, which according to my experiments are at the temperature of 8·7° or 10° (7° or 8° R.) present a striking contrast with the waters of the torrid zone, driven to the north by the *Gulf-stream*, the temperature of which is from 21° to 22·5° (17° to 18° R.). In these latitudes, the caloric is distributed in a singular manner throughout the ocean; the waters of the bank are 9·4° colder than the neighbouring sea; and this sea is 3° colder than the current. These zones can have no equilibrium of temperature, having a source of heat, or a cause of refrigeration, which is peculiar to each, and the influence of which is permanent †.

* Tableau du climat et du sol des Etats-Unis, T. 1, p. 230, Romme, Tableau des Vents, des Marées et des Courants, T. 1, p. 228.

† In treating of the temperature of the ocean, we should carefully distinguish four very different phænomena;—1st, the temperature of the water at its surface corresponding to different latitudes, the ocean being considered as in repose; 2dly,

From the bank of Newfoundland, or from the 52d degree of longitude to the Azores, the *Gulf-stream* continues its course towards the east, and the east-south-east. The waters still preserve a part of the impulsion they have received near a thousand leagues distance, in the Straits of Florida, between the Isle of Cuba, and the shoals of Tortoise island. This distance is double the length of the course of the river of the Amazons, from Jaen or the Straits of Manseriche to Grand-Para. On the meridian of the isles of Corvo and Flores, the most western of the group of the Azores, the breadth of the current is 160 leagues. When vessels, on their return from South America to Europe, endeavour to make these two islands to rectify their longitude, they constantly perceive the motion of the waters to the south-east. At the 33d degree of latitude the equinoctial current of the tropics is in the near vicinity of the *Gulf-stream*. In this part of the ocean, we may in a single day pass from waters that flow towards the west, into those which run to the south-east or east-south-east.

From the Azores, the current of Florida turns towards the Straits of Gibraltar, the Isle of Ma-

the decrement of caloric in the successive strata of the water; 3dly, the effect of the deep shoals on the temperature of the ocean; 4thly, the temperature of the currents, which cause the waters of one zone to pass with acquired velocity across the motionless waters of another zone.

deira, and the group of the Canary islands. The opening of the Pillars of Hercules has no doubt accelerated the motion of the waters towards the east. We may in this point of view assert, that the strait, by which the Mediterranean communicates with the Atlantic, produces its effects at a great distance; but it is probable also, that, without the existence of this strait, the vessels which sail to Teneriff would be driven to the south-east by a cause, which we must seek on the coasts of the New World. Every motion is the cause of another motion in the vast basin of the seas as well as in the aerial ocean. Pursuing the currents to their most distant sources, and reflecting on their variable celerity, sometimes decreasing as between the Gulf of Florida and the bank of Newfoundland; at other times augmenting, as in the neighbourhood of the Straits of Gibraltar, and near the Canary Islands, we cannot doubt but the same cause which drives the waters to make the circuitous sweep of the Gulf of Mexico, agitates them also near the Isle of Madeira.

It is to the south of this island, that we can follow the current, in its direction to the SE and SSE towards the coast of Africa, between Cape Cantin and Cape Bojador. In these latitudes a vessel becalmed is carried on the coast, at the time it is thought at a great distance, if the reckoning be not corrected. Were the motion of

the waters caused by the opening at the straits of Gibraltar, why, on the south of these straits, should it not follow an opposite direction? On the contrary, in the 25th and 26th degrees of latitude, the current flows at first directly to the south, and then to the south-west. Cape Blanc, which, after Cape Verd, is the most salient promontory, seems to have an influence on this direction, and it is in this parallel that the waters, of which we have followed the course from the coasts of Honduras to those of Africa, mix with the great current of the tropics to begin their tour from east to west. We have already observed, that, several hundred leagues to the west of the Canary islands, the motion which is peculiar to the equinoctial waters is felt in the temperate zone from the 28th and 29th degrees of northern latitude; but on the meridian of the island of Ferro, the vessels reach the south as far as the tropic of Cancer, before they find themselves, by their reckoning, to the east of their true position.

I hope to have given some value to the chart* of the Northern Atlantic Ocean, which I have

* This chart, which I began to sketch in October, 1804, beside the temperature of the sea, furnishes observations on the dip of the magnetic needle, the lines without variation, the intensity of the magnetic forces, the stripes of floating sea weeds, and other phenomena which interest physical geography.

N B. This chart, not yet engraved, will be published in the succeeding volumes.

published, by tracing in it with particular care the direction of this retrograde current, that like a river, the bed of which is gradually enlarged, traverses the vast extent of the sea. I flatter myself that the navigators, who have studied the charts of Jonathan Williams, of Governor Pownall, of Heather, and of Strickland *, will find several objects in mine worthy of their attention. Independant of the observations I have made during six voyages, namely, from Spain to Cumana, from Cumana to the Havannah, from the Isle of Cuba to Carthagena in America, from Vera Cruz to the Havannah, from this port to Philadelphia, and from Philadelphia to the coasts of France, I have collected in this map all that my laborious and active exertions could discover in the journals of such authors, as have been able to make use of astronomical means to determine the effect of the currents. I have indicated also the latitudes, in which the motion of the waters is not constantly perceived; for in the same manner as the northern limit of the current of the tropics and that of the trade winds vary according to the seasons, the gulf-stream also changes its place and direction. These changes become very perceptible from the 38th degree of latitude as far as the great bank of Newfoundland, and are observed even be-

* Amer. Trans. vol. ii, p. 328; vol. iii, p. 82 and 194; vol. v, p. 90; and an interesting essay on the currents, by M. Delamétherie. Journ. de Phys. 1808, t. 67, p. 91.

tween the 48th degree of longitude west of Paris, and the meridian of the Azores. The variable winds of the temperate zone, and the melting of the ice of the northern pole, whence in the months of July and August a great quantity of fresh water flows towards the south, may be considered as the principal causes, which modify in these high latitudes, the force and direction of the gulf-stream.

We have just seen that between the parallels of 11 and 43 degrees, the waters of the Atlantic are drawn on by the currents in a continual whirlpool. Supposing that a molecule of water returns to the same place from which it departed, we can estimate, from our present knowledge of the swiftness of currents, that this circuit of 3800 leagues is not terminated in less than two years and ten months. A boat, which may be supposed to receive no impulsion from the winds, would require thirteen months from the Canary islands to reach the coast of Carracas, ten months to make the tour of the gulf of Mexico and reach Tortoise Shoals opposite the port of the Havannah, while forty or fifty days might be sufficient to carry it from the straits of Florida to the bank of Newfoundland. It would be difficult to fix the rapidity of the retrograde current from this bank to the coasts of Africa: estimating the mean velocity of the waters at seven or eight miles in twenty-four hours, we find ten or eleven months for this last distance. Such are the effects of this slow but regular motion, which agitates

the waters of the ocean. Those of the river of the Amazons take nearly forty-five days to flow from Tomependa to Grand Para.

A short time before my arrival at Teneriff, the sea had left in the road of St. Croix a trunk of a cedrela odorata covered with the bark. This American tree vegetates exclusively under the tropics, or in the neighbouring regions. It had no doubt been torn up on the coast of the continent, or of that of Honduras. The nature of the wood, and the lichens which covered its bark, were evident proofs, that this trunk did not belong to these submarine forests, which ancient revolutions of the globe have deposited in lands transported from the polar regions. If the cedrela, instead of having been thrown on the strand of Teneriff, had been carried farther south, it would probably have made the whole tour of the Atlantic, and returned to its native soil with the general current of the tropics. This conjecture is supported by a fact of more ancient date, recorded in the general history of the Canaries by the Abbé Viera. In 1770, a small vessel laden with corn, and bound from the Island of Lancerotte, to Santa Cruz, in Teneriff, was driven to sea, while none of the crew were on board. The motion of the waters from east to west, carried it to America, where it went on shore at La Guayra near Carracas *.

* Viera Hist. gen. de las Islas Canarias, t. ii, p. 167.

Whilst the art of navigation was yet in its infancy, the gulf stream furnished the genius of Christopher Columbus with certain indications of the existence of western regions. Two corpses, the features of which indicated a race of unknown men, were thrown on the coasts of the Azores, towards the end of the 15th century. Nearly at the same period, the brother-in-law of Columbus, Peter Correa, governor of Porto Santo, found on the strand of this island pieces of bamboo of an extraordinary size, brought thither by the western currents*. These corpses and the bamboos attracted the attention of the Genoese navigator, who conjectured, that both came from a continent situate towards the west; we know at present, that in the torrid zone the trade winds and the current of the tropics are in opposition to every motion of the waves in the direction of the earth's rotation. The productions of the new world cannot reach the old, but by the very high latitudes, and in following the direction of the current of Florida. The fruit of several trees of the Antilles are often thrown on the coasts of the Isle of Ferro and Gomera. Before the discovery of America, the Canarians considered these fruits as coming from the enchanted isle of St. Borondon, which according to the reveries of the pilots, and certain legends,

* Munorz, Hist. del nuevo mundo, Lib. ii, §. 14. Fernan Colon, vida del Almirante, cap. 9. Herera Decad. 1, cap. 2.

was placed towards the west in an unknown part of the ocean, buried, as was supposed, in eternal fogs.

My chief view in tracing a sketch of the currents of the Atlantic is to prove, that the motion of the waters towards the South-east, from Cape St. Vincent to the Canary islands, is the effect of the general motion, which the surface of the Ocean feels at its western extremity. We shall give but a very succinct account of the arm of the *Gulf-Stream*, which in the 45th and 50th degrees of latitude, near the bank of Bonnet-Flamand, runs from the south-west to the north-east towards the coasts of Europe. This partial current becomes very strong when the winds have continued to blow a long time from the west: and, like that which flows along the isles of Ferro and Gomera, deposits every year on the western coasts of Ireland and Norway the fruit of trees, which belong to the torrid zone of America. On the shores of the Hebrides, we collect seeds of mimosa scandens, of dolichos urens, of guilandina bonduc, and several other plants of Jamaica, the isle of Cuba, and of the neighbouring continent*. The current carries thither also barrels of French wine, well preserved, the remains of the cargoes

* Pennant, Voyage to the Hebrides, 1772, p. 232. Gunner's Acta Nidrosiensia, t. 2, p. 310. Sloane, in the Philos. Trans. No. 222, p. 398. Linn. Amæn. Acad. vol. 2, p. 477.

of vessels wrecked in the West Indian seas*. To these examples of the distant migration of the vegetable world others no less striking may be added. The wreck of an English vessel, the Tilbury, burnt near Jamaica, was found on the coasts of Scotland. On these same coasts various kinds of tortoises are sometimes found, that inhabit the waters of the Antilles. When the western winds are of long duration, a current is formed in the high latitudes, which runs directly towards the east-south-east, from the coasts of Greenland aud Labrador, as far as the North of Scotland. Wallace relates, that twice, in 1682 and 1684, American savages of the race of the Esquimaux, driven out to sea in their leathern canoes, during a storm, and left to the guidance of the currents, reached the Orcades †. This last example is so much the more worthy of attention, as it proves at the same time how, at a period when the art of navigation was yet in its infancy, the motion of the waters of the ocean would contribute to disseminate the different races of men over the face of the globe.

The small portion of knowledge, which we hi-

* *Necker*, View of Nature in the Hebrides, in the Bibl. Brit. vol. 42, p. 90.

† James Wallace, (of Kirkwall) Account of the Islands of Orkney, 1700, p. 60. Fischer, in Pallas, Neue Nordische Beitærge, B. 3, p. 320. Greenlanders have been seen in the islands of Eda and Westram.

therto possess with respect to the absolute position and breadth of the *Gulf-Stream*, as well as its prolongation towards the coast of Europe and Africa, has been accidentally observed by a small number of enlightened men, who have crossed the Atlantic in different directions. As the knowledge of the currents is of the highest importance to shorten navigations, it would be no less useful to the pilot than the naturalist, that vessels, furnished with excellent chronometers, should cruise in the gulf of Mexico, and in the Northern Ocean between the 30th and 54th degrees of latitude, in order to determine at what distance the *Gulf-stream* is found in different seasons, and under the influence of different winds, to the south of the mouth of the Mississippi, and to the east of Capes Hatteras and Cod. The same navigators might have instructions to examine whether the great current of Florida constantly skirts the southern bank of Newfoundland; and on what parallel, between 32 and 40 degrees of west longitude, the waters which run from east to west are nearest those which follow an opposite direction.

The solution of this last problem becomes so much the more important, as the latitudes which we have just indicated are traversed by the greater part of the vessels, which return to Europe from the West India islands, or the Cape of Good Hope. Beside the direction and swift-

ness of the currents, this expedition would serve to discover the temperature of the sea at its surface, the lines without variation, the dip of the needle, and the intensity of the magnetic forces. Observations of this kind become extremely valuable, when the position of the place where they were made has been determined by astronomical means. In the seas most frequented by the Europeans, far out of sight of land, an able navigator may still devote his time to important labours. The discovery of a group of uninhabited islands is less interesting than the knowledge of those laws, which link together a considerable number of insulated facts.

In reflecting on the causes of the currents, we find, that they are much more numerous than is generally believed; for the waters of the sea may be put in motion by an external impulse, by a difference in heat and saltness, by the periodical melting of the polar ice, or by the inequality of the evaporation, which takes place in different latitudes. Sometimes several of these causes concur to the same effect, and sometimes they produce effects that are contrary. Winds that are light, but which, like the trade winds, are continually acting on the whole of a zone, cause a real movement of transition, which we do not observe in the heaviest tempests, because these last are circumscribed within a small space. When, in a great mass of water, the particles placed at the

surface acquire a different specific gravity, a superficial current is formed, which takes its direction towards the point where the water is coldest, or that which is most saturated with muriat of soda, sulphat of lime, and with muriat or sulphat of magnesia. In the seas of the tropics we find, that at great depths the thermometer marks 7 or 8 centesimal degrees. Such is the result of the numerous experiments of Commodore Ellis and of M. Peron. The temperature of the air in those latitudes being never below 19 or 20 degrees, it is not at the surface that the waters can have acquired a degree of cold so near the point of congelation, and of the maximum of the density of water. The existence of this cold strata in the low latitudes is an evident proof of the existence of an inferior current, which runs from the poles towards the equator: it also proves, that the saline substances, which alter the specific gravity of the water, are distributed in the ocean, so as not to annihilate the effect produced by the differences of temperature*.

* In fact, if the mean saltness of the sea was 0·005 greater under the equator than in the temperate zone, as several naturalists pretend, a current at the bottom, from the equator towards the pole, would be the result: for 0·005 produce a difference of density of 0·0017, while, according to the tables of Hallstrom, a refrigeration of 16 centesimal degrees, between the 20th and 4th of temperature, causes only a change of 0·00015 in the specific gravity. After attentive examina-

Considering the velocity of the molecules, which, on account of the rotatory motion of the globe, vary with the parallels, we may be tempted to admit that every current, in the direction from south to north, tends at the same time toward the east, while the waters, which run from the pole towards the equator, have a tendency to deviate toward the west. We may also be led to think, that these tendencies diminish to a certain

tion of the results of the experiments of Black, reduced by Mr. Kirwan to the temperature of 16°, I find on the average the density of the water of the sea,

from 0° to 14° latitude	at 1·0272
from 15° to 25°	1·0282
from 30° to 44°	0·0278
from 54° to 60°	1·0271

The proportion of salt corresponding to these four zones are, according to bishop Watson, 0·0374; 0·0394; 0·0386; and 0·0372. Those numbers sufficiently prove, that the experiments hitherto published do not in any way justify the renewed opinion, that the sea is salter under the equator than under the 30th and 44th degrees of latitude. It is not therefore a greater quantity of saline substance held in solution, which opposes itself to this inferior current, by which the equinoctial ocean receives particles of water, which during the winter of the temperate zones have sunk towards the bottom of the sea, from the 30th to the 44th degree of southern and northern latitude. Baumé has analysed the sea-water collected by M. Pagès in different latitudes, and found in this water 0·005 less salt at 1° 16′ of latitude than between the 25th and 40th degrees. (*Kirwan's Geol. Essays*, p, 350. *Pagès Voyage round the World*, vol. 2, p. 6 and 275.)

point the speed of the tropical current, in the same manner as they change the direction of the polar current, which in July and August, is regularly perceived during the melting of the ice, on the parallel of the bank of Newfoundland, and farther north. Very old nautical observations, which I have had occasion to confirm by comparing the longitude given by the chronometer with that which the pilots obtained by their reckoning, are contrary to these theoretical ideas. In both hemispheres, the polar currents, when they are perceived, decline a little to the east; and we think that the cause of this phænomenon should be sought in the constancy of the westerly winds which prevail in the high latitudes. Besides, the particles of water do not move with the same rapidity as the particles of air; and the currents of the ocean, which we consider as the most rapid, have only a swiftness of 8 or 9 feet a second: it is consequently very probable, that the water, in passing through different parallels, gradually acquires a velocity correspondent to those parallels, and that the rotation of the Earth does not change the direction of the currents.

The variable pressures, which the surface of the sea undergoes by the changes in the weight of the air, are another cause of motion which deserves particular attention. It is well known, that the barometric variations do not in general take place at the same moment on two distant points, which

are on the same level. If in one of these points the barometer stands a few lines lower than in the other, the water will rise where it finds the least pressure of the air, and this local intumescence will continue, till, from the effect of the wind, the equilibrium of the air is restored. Mr. Vaucher thinks that the tides in the lake of Geneva, known by the name of the *seiches,* arise from the same cause. Under the torrid zone, the horary variations of the barometer may produce small oscillations at the surface of the seas, the meridian of 4^h, which corresponds to the minimum of the pressure of the air, being situate between the meridian of 21^h and 11^h upon which the height of the mercury is the greatest; but these oscillations, if even they were perceptible, will be accompanied by no change of place*.

When this last movement is produced by the inequality of the specific weight of the particles, a double current is formed, the upper of which has a contrary direction to the lower. Thus in the greatest part of the straits, as in the seas of the tropics, which receive the cold waters of the northern regions, the whole mass of water is agitated to a very great depth. We are ignorant if it be the same, when the movement of progression, which must not be confounded with the oscillation of the waves, is the effect of an external impulse. M.

* Mouvement de translation.

de Fleurieu, in his narrative of the voyage of the Isis*, cites several facts, which render it probable that the sea is much less still at the bottom than naturalists generally admit. Without entering here into a discussion which we shall treat hereafter, we shall only observe, that, if the external impulse is constant in its action, like that of the trade winds, the friction of the particles of water on each other must necessarily propagate the motion of the surface of the ocean even to the inferior strata; and in fact this propagation in the Gulf stream has long been admitted by navigators, who think they discover the effects in the great depth of the sea wherever it is traversed by the current of Florida, even amidst the sand-banks which surround the northern coasts of the United States. This immense river of hot waters, after a course of fifty days, from the 24th to the 45th degree of latitude, or 450 leagues, does not lose, amidst the rigors of winter in the temperate zone, more than 3 or 4 degrees of the temperature it had under the tropics. The greatness of the mass, and the small conductibility of water for heat, prevent a more speedy refrigeration. If therefore the Gulf-stream has dug a channel at the bottom of the Atlantic ocean, and if its waters are in motion to considerable depths, they must also in their inferior strata keep up a lower temperature than that which is

† Voyage made by order of the king, in 1768 and 1769, to try the marine time-pieces. Vol. 1, p. 513.

observed in the same parallel, in a part of the sea which has neither currents nor deep shoals. These questions can be cleared up only by direct experiments, made by thermometrical soundings.

Sir Erasmus Gower remarks, that, in the passage from England to the Canary Islands, the current, which draws the vessels towards the south east, begins at the 39th degree of latitude. During our navigation from Corunna to the coasts of South America, the effect of this motion of the waters was perceived farther to the north. From the 37th to the 30th degree, the deviation was very unequal; the daily average effect was 12 miles, that is, our sloop drove towards the east 75 miles in six days. In cutting the parallel of the strait of Gibraltar, at a distance of 140 leagues, we had occasion to observe, that in those latitudes the maximum of the rapidity does not correspond with the mouth of the strait, but with a more northerly point, which lies in the prolongation of a line passing through the strait and Cape Saint Vincent. This line is parallel to the direction which the waters follow from the Azores to Cape Cantin. We should moreover observe, (and this fact is not uninteresting to those who examine the nature of fluids) that in this part of the retrograde current, on a breadth of 120 or 140 leagues, the whole mass of water has not the same rapidity, nor does it follow precisely the same direction. When the sea is perfectly calm, there appears at the surface

narrow stripes, like small rivulets, in which the waters run with a murmur very sensible to the ear of an experienced pilot. The 13th of June, in 34° 36′ of northern latitude, we found ourselves in the midst of a great number of these beds of currents. We took their direction with the compass; some ran north-east, others east-north-east, though the general movement of the ocean, indicated by comparing the reckoning with the chronometrical longitude, continued to be south-east. It is very common to see a mass of motionless waters crossed by threads of water, which run in different directions, and we may daily observe the phenomenon on the surface of lakes; but it is much less frequent to find partial movements, impressed by local causes on small portions of waters in the midst of a sea-river, which occupies an immense space, and which moves, though slowly, in a constant direction. In the conflict of currents, as in the oscillation of the waves, our imagination is struck by those movements which seem to penetrate each other, and by which the ocean is continually agitated.

We passed Cape St. Vincent, which is of basaltic formation, at more than eighty leagues distance. It is not distinctly seen at a greater distance than 15 leagues, but the granitic mountain called the Foya de Monchique, situate near the Cape, is perceptible, as the pilots pretend, at the

distance of 26 leagues*. If their assertion be exact, the Foya is 700 toises (1363 metres) and consequently 116 toises (225 metres) higher than Vesuvius. It seems extraordinary that the Portuguese government should neglect to maintain a fire on this point, which must be made by every vessel coming from the Cape of Good Hope or Cape Horn, and is an object for which they look with the greatest eagerness. Between Ferrol and Cadiz there is but one single light-house, that of Cape la Rocque, to direct the mariners on coasts where the approach is so dangerous. The fires on the tower of Hercules and Cape Spichel are so feeble, and so little visible at a distance, that they scarcely deserve to be cited. Besides, the convent of the Capuchins, which rises above Cape St. Vincent, would be one of the fittest places to build a light-house, with a rotatory light like that of Cadiz, or the mouth of the Garonne.

From Corunna to the 36th degree of latitude we had scarcely seen any organic being, excepting sea-swallows, and a few dolphins. We looked in vain for sea-weeds (fucus) and molluscas, when on the 11th of June we were struck with a curious sight, which afterwards was frequently renewed in the southern ocean. We entered on a zone where the whole sea was covered with a pro-

* Elementos de Navigacion de Don Dionisio Macarte, p. 47. Borda, Voy. de la Flore, vol. i, p. 39, pl. 2. Link and Hoffmansegg, Voy. en Portugal, vol. ii, p. 128; vol. iii, p. 323.

digious quantity of medusas. The vessel was almost becalmed, but the molluscas were borne towards the south-east, with a rapidity four times that of the current. Their passage lasted near three quarters of an hour. We then perceived but a few scattered individuals, following the crowd at a distance as if they were tired with their journey. Do these animals come from the bottom of the sea, which is perhaps in these latitudes some thousand fathoms deep? or do they make distant voyages in shoals? We know that the molluscas haunt banks; and if the eight rocks, near the surface, which Captain Vobonne asserts having seen in 1732, to the north of Porto Santo, really exist, we may suppose that this innumerable quantity of medusas had been thence detached; for we were but 28 leagues from this reef. We found, beside the medusa aurita of Baster, and the medusa pelagica of Bosc with eight tentacula (pelagia denticulata, Peron), a third species which resembles the medusa hysocella, and which Vandelli found at the mouth of the Tagus. It is known by its brownish-yellow colour, and by its tentaculæ, which are longer than the body. Several of these sea-nettles were four inches in diameter: their reflection was almost metallic: their changeable colours of violet and purple formed an agreeable contrast with the azure tint of the ocean.

In the midst of these medusas M. Bonpland observed bundles of dagysa notata, a mollusca of

a singular construction, which Sir Joseph Banks first discovered. These are small gelatinous bags, transparent, cylindrical, sometimes polygonal, which are thirteen lines long and two or three in diameter. These bags are open at both ends. In one of these openings, we observed a hyaline bladder, marked with a yellow spot. The cylinders are longitudinally placed on each other, like the cells of a bee-hive, and form chaplets from six to eight inches in length. I tried the galvanic electricity on these molluscas, but it produced no contraction. It appears that the genus dagysa, formed at the time of Cook's first voyage, belongs to the salpas (biphores of Bruguière) to which M. Cuvier joins the thalia of Brown, and the tethis vagina of Tilesius. The salpas journey also by groups, joining in chaplets, as we have observed of the dagysa *.

The morning of the 13th of June, in 34° 33′ latitude, we saw large masses of this last mollusca in its passage, the sea being perfectly calm. We observed during the night, that, of three species of medusas which we collected, none yielded any light but at the moment of a very slight shock. This property does not belong exclusively to the medusa noctiluca, which Forskæl has described in his Fauna Ægyptiaca, and which Gmelin has ap-

* Account of Voyages undertaken by order of his Britannic Majesty, 1789, vol. iii, p. 261. Ann. du Museum, vol. xiv. p. 360.

plied to the medusa pelagica of Lœfling, notwithstanding its red tentacula, and the brownish tuberosities of its body. If we place a very irritable medusa on a pewter plate, and strike against the plate with any sort of metal, the small vibrations of the plate are sufficient to make this animal emit light. Sometimes in galvanising the medusa, the phosphorescence appears at the moment that the chain closes, though the exciters are not in immediate contact with the organs of the animal. The fingers with which we touch it remain luminous for two or three minutes, as is observed in breaking the shell of the pholades. If we rub wood with the body of a medusa, and the part rubbed ceases shining, the phosphorescence returns if we pass a dry hand over the wood. When the light is extinguished a second time, it can no longer be reproduced, though the place rubbed be still humid and viscous. In what manner ought we to consider the effect of the friction, or that of the shock? This is a question of difficult solution. Is it a slight augmentation of temperature which favours the phosphorescence? or does the light return, because the surface is renewed, by putting the animal parts proper to disengage the phosphoric hydrogen in contact with the oxygen of the atmospheric air? I have proved by experiments published in 1797, that the shining of wood is extinguished in hydrogen gas, and in pure azotic gas, and that its light reappears whenever

we mix with it the smallest bubble of oxygen gas. These facts, to which we shall hereafter add several others, lead to the discovery of the causes of the phosphorescence of the sea, and of that peculiar influence, which the shock of the waves exercises on the production of light.

When we were between the Isle of Madeira and the coasts of Africa, we had slight breezes and dead calms, very favourable for the magnetic observations, which occupied me during this passage. We were never wearied of admiring the beauty of the nights; nothing can be compared to the transparency and serenity of an African sky. We were struck with the innumerable quantity of falling stars, which appeared at every instant. The farther progress we made towards the south, the more frequent was this phænomenon, especially near the Canaries. I have observed during my excursions, that these igneous meteors are in general more common and luminous in some regions of the globe than in others; I have never beheld them so multiplied as in the vicinity of the volcanoes of the province of Quito, and in the part of the Pacific Ocean which bathes the volcanic coasts of Guatimala. The influence, which place, climate, and seasons appear to have on the falling stars, distinguishes this class of meteors from those which give birth to stones that fall from the sky (aerolites), and which probably exist beyond the boundaries of our atmosphere. According to the

corresponding observations of Messrs. Benzenberg and Brandes *, many of the falling stars seen in in Europe were only thirty thousand toises high. One was even measured which did not exceed fourteen thousand toises, or five leagues. These measures, which can give no result but by approximation, deserve well to be repeated. In warm climates, especially under the tropics, the falling stars leave a tail behind them, which remains luminous 12 or 15 seconds: at other times they seem to burst into sparks, and they are generally lower than those in the north of Europe. We perceive them only in a serene and azure sky; they have perhaps never been seen below a cloud. Falling stars often follow the same direction for several hours, which direction is then that of the wind †. In the bay of Naples M. Gay-Lussac and myself observed luminous phænomena, very analogous to those which fixed my attention during a long abode at Mexico and Quito. These meteors are perhaps modified by the nature of the soil and the air, like certain effects of the looming ‡ and of the terrestial refraction peculiar to the coasts of Calabria and Sicily.

* Gilbert. Annalen de Physik, th. xii, p. 368.

† Such is the result of numerous observations by Mr. Arago, who, at the period of the prolongation of the meridian in Spain, was enabled to observe the direction of the meteors, during whole nights, on the Tosal d'Encanade, a mountain in the kingdom of Valentia.

‡ Mirage.

During our navigation we saw neither the Desert islands nor Madeira; I should have wished to have had the means of verifying the longitude of those islands, and of taking the angles of altitude of the volcanic mountains, which rise to the north of Funchal. M. Borda* says, that these mountains are seen at 20 leagues distance, which would give a height of only 414 toises (806 metres); but we know by recent measures, that the most elevated point† of Madeira is 5162 English feet, or 807 toises. The small Desert islands and the Salvage, on which are gathered the archil and the mesembryanthemum crystallinum, are only 200 toises in perpendicular height. I think it useful to fix the attention of navigators on these measures, because, according to a method of which this narrative offers several examples, and which Borda, Lord Mulgrave, M. de Rossel, and Don Cosmo Churruca have successfully employed in their expeditions, we may, by angles of height taken with good reflecting instruments, discover with sufficient exactness the distance, at which a vessel finds itself from a cape, or an island with mountains.

* Voy. de la Flore, vol. i, p. 65. The Salvage is visible at eight leagues; the little Desert islands are seen at 12 leagues distance. Borda, vol. i, p. 67 et 70.

† Smith's Tour of the Continent, vol. i, p. 200. Irish Trans. vol. viii, p. 124. According to Heberden, the Peak Ruivo of Madeira is 595 toises above the plane which surrounds its basis. Cook's first Voyage, vol. i, p. 272.

When we were forty leagues east of the island of Madeira, a common swallow came and perched on the topsail-yard. It was so fatigued, that it suffered itself to be easily taken. What could engage a bird, in that season, and in calm weather, to fly so far? In the expedition of d'Entrecasteaux, a common swallow was seen at 60 leagues distance from Cape Blanc; but this was towards the end of October, and M. Labillardière thought it had newly arrived from Europe. We crossed these latitudes in June, at a period when the seas had not for a long time been agitated by tempests. I dwell on this last circumstance, because small birds, and even butterflies, are sometimes forced out to sea by the impetuosity of the winds, as we observed in the southern ocean, when we were on the western coasts of Mexico.

The Pizarro had orders to touch at the isle of Lancerote *(Lanzarote,)* one of the seven great Canary islands, to inquire whether the English blockaded the road of St. Croix of Teneriff. We had been uncertain, since the 15th of June, what course to follow. Till then the pilots, to whom the use of marine watches was not very familiar, had shown little confidence in the longitude which I obtained regularly twice a day, by the difference of time, in taking horary angles morning and evening. They hesitated at steering to the south-east, in apprehension of running on Cape Nun, or at least of leaving the island of Lance-

rote to the west. At length on the 16th of June, at nine in the morning, when we were already in 29° 26′ of latitude, the Captain changed his course, and sailed toward the east. The exactness of Lewis Berthoud's timekeeper was soon recognized: at two in the afternoon we had sight of land, which appeared like a small cloud at the edge of the horizon. At five, the sun being lower, the isle of Lancerote presented itself so distinctly, that I was able to take the angle of altitude of a conic mountain, which towered majestically over the other summits, and which we thought was the great volcano which had committed so many ravages in the night of the first of September, 1730.

The current drew us toward the coast more rapidly than we wished. As we advanced, we discovered at first the island of Fortaventure *(Forteventura)* famous for the great number of camels * which it feeds; and a short time after we saw the small island of Lobos in the chan-

* These camels, which serve for labor, and sometimes for food when salted, did not exist till the Béthencourts made the conquest of the Canaries. In the sixteenth century, asses were so abundant in the isle of Fortaventura, that they became wild and were hunted. Several thousands were killed to save the harvest. The horses of Fortaventura are of singular beauty, and of the Barbary race. Noticias de la historia general de las islas Canarias, por Don Jose de Viera, t. 2, p. 436.

nel which separates Fortaventura from Lancerote. We spent part of the night on the deck. The moon illumined the volcanic summits of Lancerote, the flanks of which, covered with ashes, reflected a silver light. Antares threw out its resplendent rays near the lunar disk, which was but a few degrees above the horizon. The night was beautifully serene and cool. Though we were but a little distance from the west of Africa, and on the limit of the torrid zone, the centigrade thermometer rose no higher than 18°. The phosphorescence of the ocean seemed to augment the mass of light diffused through the air. I was able to read for the first time the nonius of a sextant, by Troughton, of two inches, the division of which was very minute, without using a taper for the limb. Several of our fellow-travellers were Canarians, who, like all other inhabitants of islands, vaunted with enthusiasm the beauty of their country. After midnight, great black clouds rising behind the volcano shrouded at intervals the moon and the beautiful constellation of the Scorpion. We beheld lights carried to and fro on shore, which were probably those of fishermen preparing for their labors. We had been employed, during our passage, in reading the ancient voyages of the Spaniards, and these moving lights recalled to our fancy those which Pedro Gutierrez, page of Queen Isabella, saw in the isle of Guanahani,

on that memorable night of the discovery of the New World.

On the 17th, in the morning, the horizon was foggy, and the sky slightly covered with vapours. The outlines of the mountain of Lancerote appeared stronger: the humidity, increasing the transparency of the air, seemed at the same time to have brought the objects nearer our view. This phænomenon is well known to those, who have made hygrometrical observations in places whence the chain of the high Alps or the Andes is seen. We passed through the channel which divides the isle of Alegranza from Montana Clara, taking soundings the whole way. We examined the Archipelago of small islands situate to the north of Lancerote, which are so ill laid down in the chart of M. Fleurieu, though it is otherwise very exact, and in that which appeared in the voyage of the Flora frigate. The chart of the Atlantic Ocean, published in 1786 by order of M. de Castries, is equally erroneous in this point. The currents being extremely rapid in these latitudes, it is important for the safety of navigators to observe here, that the position of the five small islands, Alegranza, Clara, Graciosa, Roca del Este, and Infierno, are no where laid down with exactness, but in the chart of the Canaries by Mr. de Borda, and in the Atlas of Tofino, founded for this part on the observations

of Don Jose Varela, which are nearly conformable to those of the Boussole frigate.

In the midst of this Archipelago, which is seldom traversed by vessels bound for Teneriffe, we were singularly struck with the configuration of the coasts. We thought ourselves transported to the Euganean mountains in the Vicentin, or the banks of the Rhine near Bonn*. The form of organized beings varies according to the climate, and it is that extreme variety, which renders the study of the geography of plants and animals so attractive; but the rocks, more ancient perhaps than the causes which have produced the difference of the climates on the globe, are the same in both hemispheres †. The porphyries containing vitreous feldspath and hornblende ‡, the phonolite §, the greenstone, the amygdaloids, and the basalt have forms almost as invariable as simple crystallized substances. In the Canary isands, and in the mountains of Auvergne, in the Mittelgebirge in Bohemia, in Mexico, and on the banks of the Ganges, the formation of trapp is indicated by a symmetrical disposition of the mountains, by truncated cones, sometimes insulated, sometimes grouped ‖, and by elevated plains,

* *Siebengebirge*, described by Mr. Nose.

† Monum. Amer. p. 122.

‡ *Amphibole* of Hauy.

§ *Porphyrschiefer* of Werner.

‖ *Montigemelli, Zwillingsberge.*

both extremities of which are crowned by a conical rising.

The whole western part of Lanzerota, of which we had a near view, bears the appearance of a country recently overturned by volcanic eruptions. Every thing is black, parched, and stripped of vegetable mould. We distinguished, with our glasses, stratified basalt in thin and steeply sloping strata. Several hills resembled Monte Novo, near Naples, or those hillocks of scoria and ashes, which the opening earth threw up in a single night at the foot of the volcano of Jorullo, in Mexico. In fact, the Abbé Viera* relates, that in 1730 more than half the island changed its appearance. The *great volcano*, which we have just mentioned, and which the inhabitants call the volcano of *Temanfaya*, spread desolation over a most fertile and highly cultivated region; nine villages were entirely destroyed by the lavas. This catastrophe had been preceded by a tremendous earthquake, and for several years shocks equally violent were felt. This last phænomenon is so much the more singular, as it seldom happens at the end of an eruption, when the elastic vapours have found vent by the crater, after the ejection of the melted matter. The summit of the great volcano is a rounded hill, but not entirely conic. From the angles of altitude which

* Viera, t. 2, p. 404.

I took at different distances, its absolute elevation did not appear to exceed three hundred toises. The neighbouring hills, and those of Alegranza, and Isla Clara were scarcely above one hundred or one hundred and twenty toises. We may be surprised at not finding these summits at a greater elevation, which seen at sea wear so majestic a form; but nothing is more uncertain than our judgment on the greatness of angles, which are subtended by objects close to the horizon. From illusions of this sort it arose, that before the measures * of Messrs. de Churruca and Galleano, at Cape Pilar, navigators considered the mountains of the Straits of Magellan, and those of Terra del Fuego, as being extremely elevated.

The island of Lanzerota bore formerly the name of *Titeroigotra*. On the arrival of the Spaniards, its inhabitants were distinguished from the other Canarians by marks of greater civilization. Their houses were built with free stone, while the Guanches of Teneriffe, like real troglodytes, dwelt in caverns. At Lanzerota, a very singular custom † prevailed at that time, of which

* Churruca, Apendice a la Relacion del Viaje al Magellanes, 1793, p. 76.

† Viera, t. i, p. 150, 171, 191. Du Halde, Descrip. of China, t. iv, p. 461. In Thibet, polyandry is nevertheless much less common than is thought, and is blamed by the clergy. Hackman in Pallas, Neue Nordische Beitræge, B. 3, p. 282.

we find no example except among the people of Thibet. A woman had several husbands, who alternately enjoyed the prerogatives due to the head of a family. A husband was considered as such only during a lunar revolution, and whilst his rights were exercised by others, he remained classed among the household domestics. It must be regretted, that the missionaries who accompanied Jean de Béthencourt, and who sketched the history of the conquest of the Canaries, have given us no ampler details on the manners of a people who had such singular customs. In the fifteenth century, the island of Lanzerota contained two small distinct states, divided by a wall; a kind of monuments which outlive national enmities, and which we find in Scotland, in China, and Peru.

We were forced by the winds to pass between the islands of Alegranza and Montana Clara; and as none on board the sloop had sailed through this passage, we were obliged to be continually sounding. We found from twenty five to thirty two fathom. The lead brought up an organic substance of so singular a construction, that we were for a long time doubtful whether it was a zoophite or a kind of seaweed. The drawing I made on the spot is engraved in the second volume of our Equinoctial Plants *. The stem, of

* Equinox. Plants. t. ii; p. 8, pl. 69.

a brownish color and three inches long, has circular leaves that have lobes, and are indented at the edge. The colour of these leaves is a tender green, and they are membranous and streaked like those of the adiantums and the ginkgo biloba. Their surface is covered with stiff and whitish hairs; before their opening they are concave and envelloped one in the other. We observed no mark of spontaneous motion, no sign of irritability, not even on the application of galvanic electricity. The stem is not woody, but almost of a horny substance, like the stem of the gorgons. Azote and phosphorus having been abundantly found in several cryptogamous plants, an appeal to chemistry would be useless, to determine whether this organized substance belonged to the animal or vegetable kingdom. Its great analogy to several sea plants, with adiantum leaves, especially with the genus caulerpa of M. Lamoureux, of which the fucus prolifer of Forskal is one of the numerous species, engaged us to rank it provisionally among the *sea-wracks*, and give it the name of fucus vitifolius. The bristles which cover this plant are found in several other fuci*. The leaf, examined with a microscope at the instant we drew it up from the water, did not present, it is true, those *conglobate* glands, or those opake points, which the parts

* Fucus lycopodioïdes, and f. hirsutus.

of fructification in the genera of ulva and fucus contain; but how often do we find sea-weeds in such a state, that we cannot yet distinguish any trace of seeds in their transparent parenchyma.

I should not have entered into these details, which belong to descriptive natural history, had not the vine-leaved fucus presented a physiological phenomenon of the greatest interest. Fixed to a piece of madrepora, this seaweed vegetates at the bottom of the ocean, at the depth of 192 feet, notwithstanding which, its leaves were as green as those of our grasses. According to the experiments of Bouguer*, light is weakened after a passage of 180 feet in the ratio of 1 to 1477·8. The sea-weed of L'Alegranza consequently presents a new example of plants, which vegetate in a great obscurity without being whitened. Several germs, still enveloped in the bulbs of the lily tribes, the embryo of the malvaceæ, of the rhamnoïdes, of the pistacea, the viscum, and the citrus, the branches of some subterraneous plants; in short, vegetables transported into mines, where the ambient air contains hydrogen, or a great quantity of azote,

* Traité d'optique, p. 256, 264, 346. The fucus vitifolius, at the depth of 32 fathoms, can have received a light only 203 times stronger than that of the moon, and consequently equal to half the light of a candle at a foot's distance. But after my direct experiments, the lepidium sativum scarcely takes a tint of green by the vivid light of two lamps of Argand. See also Lambert, Photometria, p. 223.

become green without light. From these facts, we are inclined to admit, that it is not only under the influence of the solar rays that this carburet of hydrogen is formed in the organs of plants, the presence of which makes the parenchyma appear of a lighter or darker green, according as the carbon predominates in the mixture*.

Mr. Turner, who has so well made known the family of the seaweeds, and many other celebrated botanists, think that the greater part of the fuci which we gather on the surface of the ocean, and which from the 23d to the 35th degree of latitude, and 32d of longitude, appear to the mariner like a vast inundated meadow, grow primitively at the bottom of the ocean, and float only in their ripened state, when they are torn off by the motion of the waves. If this opinion be founded, we must agree, that the family of seaweeds offers formidable difficulties to naturalists, who persist in thinking, that absence of light must always produce a whiteness; for how can we admit, that so many species of ulvaceæ, and dictyoteæ, with stems and green leaves, which float on the ocean, have vegetated on rocks almost at the surface of the water?

* These ideas are in part explained in my memoir on the phenomenon of *etiolation*, (*Journal de Physique*, t. 40, p. 154) and in my *Aphorisms on the chemical physiology of Vegetables*. (*Flora Freibergensis*, p. 179). See also *Trans. of the Irish Academy*, vol. 8, p. 260.

From some notions which the captain of the Pizarro had collected in an old Portuguese itinerary, he thought himself opposite a small fort, situate at the north of Teguisa, the capital of the island of Lanzerota. Mistaking a rock of basalt for a castle, he saluted it by hoisting the Spanish flag, and sent a boat with an officer to inquire of the commander if the English vessels were cruizing in the roads. We were not a little susprised to learn, that the land, which we had considered as a prolongation of the coasts of Lanzerota, was the small island of Graciosa, and that for several leagues there was not an inhabited place.

We took advantage of the boat to survey the land, which enclosed a large bay. No language can express the emotion, which a naturalist feels, when he touches for the first time a land that is not European. The attention is fixed on so great a number of objects, that he can scarcely define the impression he receives. At every step he thinks he discovers some new production; and in this tumultuous state of mind he does not recollect those which are most common in our botanical gardens, and collections of natural history. At two hundred yards from the coast, we saw a man fishing with a line. We steered towards him, but he took fright, and hid himself behind a rock. The sailors brought him back with difficulty. The sight of the sloop, the fire of the cannon in so solitary a place, though sometimes visited by Bar-

bary corsairs, and the landing of the crew, had frightened this poor man. He informed us, that the small island of Graciosa, on which we had just landed, was separated from Lanzerota by a narrow channel called El Rio. He offered to conduct us to the port of Los Colorados, to get information respecting the blockade of Teneriffe, but as he assured us at the same time, that he had not seen any vessel for some weeks on the seas, the captain resolved to pursue his course to Santa Cruz.

The small part of the island of Graciosa, which we traversed, resembles those promontories of lava, which we see near Naples, between Portici and Torre del Greco. The rocks are naked, with no marks of vegetation, and scarcely any of vegetable soil. A few crustaceous lichen variolariæ, leprariæ, and urceolariæ * were scattered about upon the basaltes. The lavas which are not covered with volcanic ashes remain for ages without any appearance of vegetation. On the African soil excessive heat, and lengthened drought, retard the growth of cryptogamous plants.

* We found the lecidea astrovirens, urceolaria ocelleta, u. diamarta, (to which M. Achariur assimilates the lichen kœnigri of my Flora of Friberg) parmelia parietina, p. tenella, (lichen hispidus Willd.) p. atra, lecidia fusco-atra, and many other species, which were hitherto thought to belong exclusively to the north of Europe. (Achar. Methodus Lichenum, t. 1, p. 152

The basalts of Graciosa are not in columns, but divided into strata 10 or 15 inches thick. These strata are inclined under an angle of 80 degrees to the north-west. The compact basalt alternates with the strata of porous basalt and marl. The rock does not contain hornblende, but great crystals of foliated olivine, which have a triple *clivage**. This substance is decomposed with great difficulty. M. Haüy considers it as a variety of the pyroxene. The porous basalt, which passes into *mandelstein*, has oblong cavities from two to eight lines diameter, lined with chalcedony, enclosing fragments of compact basalt. I did not remark that these cavities had the same direction, or that the porous rock lay on compact strata, as happens in the currents of lava of Ætna and Vesuvius. The marl†, which alternates more than a hundred times with the basalts, is yellowish, friable by decomposition, very coherent in the inside, and often divided into irregular prisms, analogous to the basaltic prisms. The sun discolors their surface, as it whitens several schists, by reviving a hydrocarburetted principle, which appears to be combined with the earth. The marl of Graciosa contains a great quantity of chalk, and strongly effervesces with nitric acid, even on points where it is found in contact with the basalt. This fact is so much more remarkable, as this substance does not fill

* Blættriger olivin.

† Mergel.

the fissures of the rock, but its strata are parallel to those of the basalt; whence we may conclude, that both fossils are of the same formation, and have a common origin. The phænomenon of a basaltic rock containing masses of indurated marl split into small columns, is also found in the Mittelgebirge, in Bohemia. Visiting those countries in 1792, in company with Mr. Freiesleben*, we even recognized in the marl of the Stiefelberg the imprint of a plant nearly resembling the cerastium, or the alsine. Are these strata, contained in the trappean mountains, owing to muddy irruptions? or must we consider them as sediments of water, which alternate with volcanic depositions? This last hypothesis seems so much the less admissible, since, from the researches of Sir James Hall on the influence of pressure in fusions, the existence of carbonic acid in substances contained in basalt offers nothing surprising. Several lavas of Vesuvius present similar phænomena. In Lombardy, between Vicenza and Abano, where the calcareous stone of the Jura† contains great masses of basalt, I have seen this latter enter into effervescence with the acids wherever it touches the calcareous rock.

We had not time to reach the summit of a hill, that was very remarkable in having its base formed of banks of clay under strata of basalt, like a

* Bergmænnisches Journal, 1792, p. 215.

† Jura-kalkstein.

mountain in Saxony *, which is become celebrated on account of the disputes of volcanean and neptunean geologists. These basaltes were covered with a mammæform substance, which I vainly sought on the Peak of Teneriffe, and which is known by the name of volcanic glass, glass of Muller or Hyalite: it is the transition from the opal to the calcedony. We struck off with difficulty some fine specimens, leaving masses that were eight or ten inches square untouched. I never saw in Europe such fine hyalites as I found in the island of Graciosa, and on the rock of porphyry called *el Peñol de los Bannos*, on the bank of the lake of Mexico.

Two kinds of sand cover the shore; one is black and basaltic, the other white and quartzose. In a place exposed to the rays of the sun, the first raised the thermometer to 51·2° (41° R.) and the second to 40° (32° R.) The temperature of the air in the shade was 27·7° or 7·5° higher than that of the air over the sea. The quartzose sand contains fragments of feldspath. It is thrown back by the water, and forms, in some sort, on the surface of the rocks, small islets where the seaweed vegetates. Fragments of granite have been observed at Teneriffe; the island of Gomora, from the details furnished me by Mr. Broussonnet, contains a nucleus of micaceous schist†; the quartz disseminated in the sand, which we found

* Scheibenbergen huegel.

† Glimmerschiefer.

on the shore of Graciosa, is a different substance from the lavas, and the trappean porphyries which are so intimately connected with the volcanic productions. From these facts it seems evident, that in the Canary islands, as well as on the Andes of Quito, in Auvergne, Greece, and the greater part of the globe, the subterraneous fires have pierced through the rocks of primitive formation. In treating hereafter of the great number of warm springs, which we have seen issuing from granite, gneiss, and micaceous schist, we shall have occasion to return to this subject, which is one of the most important of the physical history of the globe.

We reembarked at sunset, and hoisted sail, but the breeze was too feeble to permit us to continue our course to Teneriffe. The sea was calm; a reddish vapor covered the horizon, and seemed to magnify every object. In this solitude, amidst so many uninhabited islets, we enjoyed for a long time the view of an austere and savage nature. The black mountains of Graciosa appeared like perpendicular walls of five or six hundred feet. Their shadows, thrown over the surface of the ocean, gave a gloomy aspect to the scenery. Rocks of basalt, emerged from the bosom of the water, wore the resemblance of the ruins of some vast edifice; their existence carried our thoughts back to the remote period when submarine volcanoes gave birth to new islands, or rent the continents asunder. Every thing which surrounded us seemed

to indicate destruction and sterility; but the back ground of the picture, the coasts of Lanzerota, presented a more smiling aspect. In a narrow pass, between two hills, crowned with scattered tufts of trees, the marks of cultivation were visible. The last rays of the sun gilded the corn ready for the sickle. The desert even is animated wherever we can discover a trace of the industry of man.

We endeavoured to get out of this bay by the pass which separates Alegranza from Montana Clara, and through which we had easily entered to land at the northern point of Graciosa. The wind having fallen, the currents drove us very near a rock, on which the sea broke with violence, and which is noted in the old charts under the name of Hell, or Infierno. As we examined this rock at the distance of two cables length, we found that it was a mass of lava three or four fathoms high, full of cavities, and covered with scoriæ resembling coke. We may presume that this rock *, which modern charts call the West Rock (Roca del Oeste), was raised by volcanic fire; and it might

* Borda, Voyage de la Flore, vol. i, p. 386. Bory St. Vincent, Essai sur les Iles Fortunées, p. 20. I must here observe, that this rock is already noted on the celebrated venetian chart of Andrea Bianco, but that the name of *Inferno* is given, as in the most ancient chart of Picigano, made in 1367, to Teneriff, without doubt because the Guanches considered the peak as the entrance into Hell. In the same latitudes an island made its reappearance in 1811.

heretofore have been much higher; for the *new island* of the Azores, which rose from the sea, at successive periods, in 1638 and 1719, had reached 354 feet* when it totally disappeared in 1723, to the depth of 480 feet. This opinion on the origin of the basaltic mass of the Infierno is confirmed by a phenomenon, which was observed towards the middle of the last century in these same latitudes. At the time of the irruption of the volcano of Temanfaya, two pyramidal hills of lithoid lava rose from the bottom of the ocean, and united themselves by degrees to the island of Lancerote.

As we were prevented by the fall of the wind, and by the currents, from repassing the channel of Alegranza, we resolved on tacking during the night between the isle Clara and the West Rock. This resolution had nearly proved fatal. A calm is very dangerous near this last rock, towards which the current drives with considerable force. We began to feel the effects of this current at midnight. The proximity of the stony masses, which rise perpendicularly above the water, deprived us of the little wind which blew: the sloop no longer obeyed the helm, and we dreaded striking every instant. It is difficult to conceive how a mass of basalt, insulated in the vast expanse of the ocean, can

* In 1720, this island was visible at seven or eight leagues distance. Mem. de l'Académie, 1722, p. 12. Fleurieu, Voyage de l'Isis, vol. i, p. 565.

cause so considerable a motion in the waters. These phenomena, well worthy the attention of naturalists, are nevertheless well known to mariners; they are extremely to be dreaded in the Pacific Ocean, particularly in the small Archipelago of the islands of Gallipagos. The difference of temperature which exists between the fluid and the mass of rocks cannot explain the direction which these currents take; and how can we admit, that the water is engulfed at the base of these rocks, which often are not of volcanic origin; and that this continual engulfing determines the particles of water to fill up the vacuum that takes place* ?

The wind having freshened a little towards the morning on the 18th, we succeeded in passing the channel. We drew very near the Inferno the second time, and remarked the large crevices, through which the gazeous fluids probably issued, when this basaltic mass was raised. We lost sight of the small islands of Alegranza, Montana Clara, and Gracioza, which appear to have never been inhabited by the Guanches. They are now visited only to gather archil; this production is however less sought after, since so many other lichens

* We are surprised to read in a highly useful work, which is in the hand of every seaman, in the ninth edition of Hamilton Moore's Practical Navigator, p. 200, that it is by the effect of the attraction of the masses, or of universal gravitation, that a vessel leaves the coasts with difficulty, and that the boat of a frigate is attracted by the frigate itself.

of the north of Europe yield other materials proper for dyeing. Montana Clara is noted for its beautiful Canary birds. The note of these birds varies with their flocks, like that of our chaffinches, which often differs in two neighbouring districts. Montana Clara yields pasture for goats, which proves that the interior of this islet is less arid than its coasts. The name of Alegranza is synonimous with the Joyous *, which was given it by the first conquerors of the Canary Islands, two Norman barons, Jean de Béthencourt, and Gadifer de Salle. This was the first point on which they landed. After remaining several days at Graciosa, a small part of which we examined, they conceived the project of taking possession of the neighbouring isle of Lanzerota, where they were welcomed by Guadarfia, sovereign of the Guanches, with the same hospitality that Cortez found in the palace of Montezuma. The shepherd king, who had no other riches than his goats, became the victim of coward treachery, like the sultan of Mexico.

We sailed along the coasts of Lanzerota, of the island of Losbos, and of Fortaventura. The second of these islands seems to have anciently formed part of the two others. This geological hypothesis was started in the seventeenth century by a franciscan, Juan Galindo. This writer even supposed that, the king, Juba, had named six Canary

* La Joyeuse.

Islands only, because, in his time, three among them were contiguous. Without admitting the small probability of this hypothesis, learned geographers have seemed to recognize, in the Archipelago of the Canaries, the two isles Junoniæ, Nivaria, Ombrios, Canaria, and the Capraria of the ancients*.

The haziness of the horizon prevented us, during the whole of our passage from Lanzerota to Teneriffe from discovering the summit of the peak of Teyde. If the height of this volcano is 1905 toises, as the last trigonometrical measure of Borda indicates, its summit ought to be visible at a distance of 43 leagues, supposing the eye on a level with the ocean, and a refraction equal to 0·079, of distance. It has been doubted† whether the peak has ever been seen from the channel, which separates Lanzerota from Fortaventura, and which is distant from the volcano, according to the chart of Varela, 2 29′, or nearly 50 leagues. This phenomenon appears nevertheless to have been verified by several officers of the Spanish royal marine. I had in my hand, on board the Pizarro, a journal, in which it was noted, that the peak of Teneriffe had been seen at 135 miles dis-

* Gosselin, Rech. sur la Géog. des Anciens, t. i, p. 146, 156, 163.

† Voyage de la Flore, t. i, p. 380. My chronometer gave me, on the coast north-west of Lanzerota, 15° 52′ 10″ west of the meridian of Paris.

tance, near the southern cape of Lanzerota, called Pichiguera. Its summit was discovered under an angle considerable enough to lead the observer, Don Manuel Baruti, to think that the volcano might have been visible at nine miles farther. It was in September, towards the evening, and in very damp weather. Reckoning fifteen feet for the elevation of the eye, I find, that to render an account of this phænomenon, we must suppose a refraction equal to 0·158 of the arch, which is not very extraordinary for the temperate zone. According to the observations of General Roy, the refractions vary in England from one twentieth to one third; and if it be true, that they reach these extreme limits on the coast of Africa, which I much doubt, the peak, in certain circumstances, may be seen on the deck of a vessel as far off as 61 leagues.

Navigators who have much frequented these latitudes, and who can reflect on the physical causes of the phænomena, are surprised that the peaks of Teyde and of the Azores * are sometimes

* The height of this peak, according to Fleurieu, is 1100 toises; to Ferrer, 1238 toises; and to Tofino, 1260 toises: but these measures are only approximative estimations. The captain of the Pizarro, Don Manuel Cagigal, proved to me, by his journal, that he observed the peak of the Azores at the distance of 37 leagues, when he was sure of his latitude within two minutes. The volcano was seen at S. 4° E., so that the error in longitude must have an almost imperceptible in-

visible at a very great distance, though at other times they are not seen when the distance is much less, and the sky appears serene and the horizon free from fogs. These circumstances are so much the more worthy the attention of naturalists, as several vessels returning to Europe wait impatiently for a sight of these mountains, to rectify their longitude, and think themselves much farther off than they really are, when in fine weather these peaks are not perceptible at distances where the angles subtended ought to be very considerable. The constitution of the atmosphere has a great influence on the visibility of distant objects. It may be admitted in general, that the peak of Teneriffe is seldom seen at a great distance, in the warm and dry months of July and August, and that on the contrary it is seen at very extraordinary distances in the months of January and February, when the sky is slightly covered, and immediately after a heavy rain, or a few hours before it falls. It appears, that the transparency of the air is prodigiously increased, as we have already observed, when a certain quantity of water is uniformly diffused through the atmosphere. Independant of these observations, it is not astonishing, that the

fluence in the estimation of the distance. Nevertheless, the angle which the peak of the Azores subtended was so great, that Mr. Cagigal thinks this volcano must be visible at more than 40 or 42 leagues. The distance of 37 leagues supposes an elevation of 1431 toises.

peak of Teyde should be seldomer visible at a very remote distance, than the summits of the Andes, which were so long under my observations. This peak, inferior in height to those parts of the chain of Mount Atlas, at the foot of which is the city of Morocco, is not, like those points * covered with perpetual snows. The *Piton*, or *Sugar Loaf*, which terminates the peak, no doubt reflects a great quantity of light, on account of the whitish colour of the pumice stone thrown up by the crater; but the height of this little truncated cone does not form a twenty-secondth part of the total elevation. The flanks of the volcano are covered either with blocks of black and scorified lava, or with a luxuriant vegetation, the masses of which reflect so much the less light, as the leaves of the trees are separated from each other by shadows of more considerable extent than that of the part which is enlightened.

Hence it results, that setting aside the *Piton*, the Peak of Teyde is in the class of those mountains, which, according to the expression of Bouguer, are seen at considerable distances only in a *negative manner*, because they intercept the light which is transmitted to us from the extreme limits of the atmosphere; and that we perceive their existence only on account of the difference of intensity, which subsists between the aerial light

* According to Haest, and Jackson, Account of the Empire of Morocco, p. 13.

which surrounds them, and that which is reflected by the particles of air placed between the mountains and the eye of the observer*. As we withdraw from the isle of Teneriffe, the *Piton* or *Sugar Loaf* is seen for a long time in a *positive manner*, because it reflects a whitish light, and clearly detaches itself from the sky; but as this cone is only 80 toises high, by 40 in breadth at its summit, it has recently been a question†, whether from the diminutiveness of its mass it can be visible at distances which exceed 40 leagues; and if it be not rather probable, that navigators distinguish the peak as a small cloud above the horizon, only when the base of the Piton begins to be *visible* on it. If we admit, that the mean breadth of the Sugar Loaf is 100 toises, we find that the little cone, at 40 leagues distance, still subtends, in the horizontal direction, an angle of more than three minutes. This angle is considerable enough to render an object visible; and if the height of the Piton greatly exceeded its basis, the angle in the horizontal direction might be still smaller, and the object still continue to make an impression on our organs;

* Traité d'Optique, p. 365. It follows from the experiments of the same author, in order that this difference may become perceptible to our organs, and the mountain detach itself distinctly from the sky, that one of these lights should be a sixtieth part stronger than the other.

† Marchand, t. 2, p. 10.

for micrometrical observations have proved, that the limit of vision is but a minute only, when the dimensions of the objects are the same in every direction. We distinguish at a distance, by the eye only, trunks of trees insulated in a vast plain, though the subtended angle be under twenty five seconds.

As the visibity of an object, which detaches itself in a brown color, depends on the quantities of light which the eye meets with on two lines, one of which ends at the mountain, and the other reaches on to the surface of the aerial ocean, it follows that the farther we remove from an object, the smaller the difference becomes between the light of the surrounding atmosphere, and that of the strata of air placed before the mountain. It is on this account, that, when less elevated summits begin to appear above the horizon, they present themselves at first under a darker tint, than those we discover at very great distances. In the same manner, the visibility of the mountains, which are seen only in a negative manner, does not depend solely on the state of the lower regions of the air, to which our meteorological observations are limited, but also on its transparency and physical constitution in the most elevated parts; for the image detaches itself better in proportion as the aerial light, which comes from the limits of the atmosphere, has been originally more intense, or rather has undergone less loss in its passage. This consideration explains to a certain point, why, under a perfectly

serene sky, the state of the thermometer and the hygrometer being precisely the same in the air which is nearest the Earth, the peak is sometimes visible, and at other times invisible, to navigators at equal distances. It is even probable, that the chance of perceiving this volcano would not be greater, if the ashy cone, at the summit of which is the mouth of the crater, were equal, as in Vesuvius, to a quarter of the total height. These ashes which are pumice stone crumbled into dust, do not reflect as much light as the snow of the Andes; are the cause why the mountain, seen from afar, without detaching itself in a bright, detaches itself more feebly in a brown color; and contribute, if we may use the expression, to equalize the portions of aerial light, the variable difference of which renders the object more or less distinctly visible. Calcareous mountains, stripped of vegetable earth, summits covered with granitic sand, the high savannahs of the Cordilleras*, which are of a golden yellow, are undoubtedly distinguished at small distances better than objects which are seen in a negative manner; but the theory indicates a certain limit, beyond which these last detach themselves more distinctly from the azure vault of the sky.

The colossal summits of Quito and Peru, tow-

* *Los Pajonales*, from *paja*, straw. It is the name of the *region of the gramina*, which encircles the zone of the perennial snows. Géogr. vég. p. 70.

ering above the limit of the perpetual snows, concentre all the advantages, which render them visible under very small angles. We have stated, that the circular summit of the peak of Teneriff is only a hundred toises in diameter. According to the measures I made at Riobamba, in 1803, the dome of the Chimborazo, 153 toises below its summit, consequently in a point which is 1300 toises higher than the peak, is still 673 toises (1312 metres) in breadth. The zone of perennial snows also forms a fourth of the height of the mountain; and the base of this zone, seen on the coast of the Southern Ocean, fills an extent of 3437 toises (6700 metres). But though Chimborazo is two thirds higher than the peak, we do not see it, on account of the curve of the globe, at more than 38 miles and a third farther *. The radiant brilliancy of its snows, when at the port of Guayaquil, at the end of the rainy season, it is discovered at the horizon, may lead us to suppose, that it must be seen at a very great distance in the South Sea. Pilots highly worthy of credit have assured me, that they have seen it from the rock of Muerto, to

* Without attending to the refraction, the Peak of Teneriffe (1904 toises) is visible at 1° 57′ 22″, Mount Blanc (2440 toises) at 2° 13′ 0″, and Chimborazo (3350 toises) at ° 35230″. The mean refraction, supposed to be 0·08, augments this distance, as to Chimborazo, only fourteen miles.

the south west of the isle of Puna, at a distance of 47 leagues*. Whenever it has been seen at a greater distance, the observers, uncertain of their longitude, have not been in a situation to furnish precise data.

The aerial light, projected on the mountains, increases the visibility of those which are seen positively; its energy diminishes, on the contrary, the visibility of the objects, which, like the peak of Teneriffe and that of the Azores, detach themselves in a brown tint. Bouguer, building on theoretical considerations, found that according to the constitution of our atmosphere, the mountains seen negatively cannot be perceived at distances which exceed 35 leagues†. It is impor-

* According to the charts of the *Deposito hydrografico* of Madrid. [Admitting 1° 13′ 32″ for the difference of the meridians of Guayaquil and Quito, such as I found it (*Observ. Ast.* t. ii, p. 298, 357, and 433) the Muerto is a little less distant than Chimborazo.

† If, according to the theory of Bouguer, (*Traité d' Optique*, p. 360) the intensity of the aërial colour, which is reflected by the whole of the atmosphere towards the horizon in a determinate direction, is equal to $\frac{2575}{10000}$ q.; the intensity, after a passage of 30 leagues, would be $\frac{2525}{10000}$ q. This quantity differs from the other a little more than one sixtieth, whilst after a passage of 45 leagues, the intensity of the aerial colour is already $\frac{2565}{10000}$ q., which differs too little from $\frac{2575}{10000}$ q. for the difference to be perceived by our organs. From these data we find by interpolation, that the visibility should have ceased at 35 leagues distance.

tant here to observe, that these calculations are contrary to experience. The peak of Teneriffe has been often seen at 36, 38, and even at 40 leagues. Moreover, in the vicinity of the Sandwich islands, the summit of Mowna Roa*, at a season when it was without snows, was seen on the skirt of the horizon, at the distance of 53 leagues. This is the most striking example we have hitherto known of the visibility of a mountain; and what is the more remarkable, it is an

* The height of Mowna Roa, according to Marchand, is more than 2598 toises; according to King, it is 2577 toises; but these measures, notwithstanding their accidental concordance, are not founded on very exact measurements. It is a very extraordinary phænomenon, to see a summit placed in the 19th degree of latitude, and which is probably 2500 toises high, entirely stripped of its snows. The very flattened form of Mowna Roa, the *Mesa* of the old Spanish charts, its insulated situation in the midst of the ocean, and the frequency of certain winds, which, modified by the ascending current, blow obliquely, may be the principal causes. It is difficult to believe, that captain Marchant was much deceived in the estimation of the distance at which he saw, on the 10th of October 1791, the summit of Mowna Roa. He had left the island of Owhyhee only the 7th in the evening; and from the movement of the waters, and the lunar observations of the 19th, it is probable that the distance was even greater than 53 leagues. Besides, an experienced navigator, Mr. Fleurieu, relates, that at a distance of 35 or 36 leagues the peak of Teneriffe is visible, even in weather that is not perfectly clear. *Voy. de Marchand*, vol. i, p. 408 and 427; vol. ii, p. 10 and 78.

object seen negatively which furnishes the example.

I thought it proper to bring together these considerations at the end of this chapter, because in treating so closely on one of the most important problems of optics, that of the diminution of light in its passage across the strata of the atmosphere, they may be at the same time of some practical utility. The volcanoes of Teneriffe, and of the Azores, the Sierra Nevada of St. Martha, the peak of Orizaba, the Silla of Caraccas, Mowna Roa, and Mount St. Elias, insulated in the vast extent of the seas, or placed on the coasts of continents, serve as sea marks to direct the pilot, who is deprived of the means fitted to determine the position of the vessel by the observation of the stars; every thing, which has a relation to the visibility of these natural seamarks, is interesting to the safety of navigation.

CHAPTER II.

Stay at Teneriffe — Journey from Santa Cruz to Orotava. — Excursion to the top of the Peak of Teyde.

From the time of our departure from Graciosa, the horizon continued so hazy, that notwithstanding the considerable height of the mountains of Canary *, we did not discover this island till the evening of the 18th of June. It is the granary of the archipelago of the Fortunate islands, and what is very remarkable in a region situate beyond the limits of the tropics, we were assured, that in some districts, there are two wheat harvests in the year; one in February, and the other in June †. Canary has never been visited by a learned mineralogist; yet this island is so much the more worthy of observation, as the physiognomy of its mountains, disposed in parallel chains, appeared to me to differ entirely from that of the summits of Lanzerota and Teneriffe.

* Isla de la Gran Canaria.

† Ledra, Voyage à Teneriffe, t. i, p. 37.

Nothing is more interesting for the geologist, than to observe the relations, on the same point of the globe, between volcanic countries, and those which are primitive or secondary. When the Canary islands shall have been some day examined in all the parts, which compose the system of these mountains, we shall find, that we have been too precipitate in considering the whole group as raised by the action of submarine fires.

The 19th, in the morning, we discovered the point of Naga*, but the peak of Teneriffe was still invisible: the land, obscured by a thick fog, presented forms that were vague and confused. As we approached the road of Santa Cruz, we observed that these vapours, driven by the winds, drew nearer. The sea was strongly agitated, as it most commonly is in those latitudes. We anchored after several soundings, for the mist was so thick, that we could scarcely distinguish objects at a few cables' distance; but at the moment we began to salute the place, the fog was instantly dispelled. The Peak of Teyde appeared in a break above the clouds, and the first rays of the sun, which had not yet risen on us, illuminated the summit of the volcano. We hastened toward the bow of the vessel, to enjoy the magnificent spectacle, when at the same instant we saw four

* *Punta de Naga, Anaga, or Nago.*

English ships of the royal navy lying to very near the poop. We had passed without being perceived; and the same mist, which had hidden the peak from our view, had saved us from the danger of being carried back to Europe. It would have been very painful to naturalists, to have seen the coast of Teneriffe, without having been able to tread a soil torn up by volcanoes.

We immediately got up our anchor, and the Pizarro stood in as close as possible to the fort, to be under its protection. It was on this shore, that, in the landing attempted by the English two years before our arrival *, admiral Nelson had his arm carried of by a cannon ball. The governor general of the Canaries † sent an order to the captain of the sloop, to put on shore the dispatches from the court for the governors of the colonies, the money on board, and the public correspondence. The English vessels left the road, having given chace the evening before to the packet boat the *Alcudia*, which had left Corunna a few days before us. She was obliged to touch at the port of Palmas, in the isle of Canary, and several passengers, who were going in a boat to Santa Cruz, had been made prisoners.

The situation of this town is very similar to that

* In the month of July, 1797.

† Don Andrea de Perlasca.

of La Guayra, the most frequented port of the province of Caraccas. The heat is excessive in both places, and from the same causes; but the aspect of Santa Cruz is more gloomy. On a narrow and sandy beach, houses of dazzling whiteness, with flat roofs, and windows without glass, are stuck against a wall of black perpendicular rocks, stripped of vegetation. A fine mole, built of free stone, and the public walk planted with poplars, are the only objects, which break the sameness of the landscape. The view of the peak, such as it presents itself above Santa Cruz, is much less picturesque than that we enjoy from the port of Orotava. There, a highly cultured and smiling plain offers a pleasing contrast with the wild aspect of the volcano. From the groups of palm trees and bananas, which line the coast to the region of the arbutus, the laurel, and the pine, the volcanic rock is crowned with luxuriant vegetation. We easily conceive how the inhabitants, even of the beautiful climates of Greece and Italy, fancied that they recognised one of the Fortunate Isles in the western part of Teneriffe. The eastern side, that of Santa Cruz, on the contrary, is every where struck with the marks of sterility. The summit of the peak is not more arid than the promontory of basaltic lavas, which stretches towards the point of Naga, and on which succulent plants, springing up in the clefts of the rocks, scarcely indicate a preparation of soil. At the port of Orotava, the top of the Piton subtends

an angle in height of more than eleven degrees and a half; whilst at the mole of Santa Cruz* this angle scarcely exceeds 4°. 36′.

Notwithstanding this difference, and though in the latter place the volcano rises above the horizon scarcely as much as Vesuvius seen from the mole of Naples, the aspect of the peak is still very majestic, when those who anchor in the road discover it for the first time. The Piton alone was visible to us; its cone projected itself on a sky of the purest blue, whilst dark thick clouds enveloped the rest of the mountain to the height of 1800 toises. The pumice stone, illumined by the first rays of the sun, reflected a reddish light, like that which paints the summits of the higher Alps. This light by degrees becomes a dazzling whiteness; and, deceived like the greater part of travellers, we thought that the peak was still covered with snows, and that we should with difficulty reach the edge of the crater.

We have remarked, in the Cordilleras of the Andes, that the conical mountains, such as Cotopaxi and Tungurahua, are oftener seen free from clouds, than those mountains, the tops of which are broken into bristly points, like Antisana and Pichincha; but the peak of Teneriffe, notwithstanding its pyramidical form, is a great part of the year enveloped in vapours, and

* The oblique distance from the top of the volcano to Orotava and to Santa Cruz are nearly 8600 toises and 22500 toises.

is sometimes, during several weeks, invisible from the road of Santa Cruz. Its position to the west of an immense continent, and its insulated situation in the midst of the seas, are no doubt the causes of this phenomenon. Navigators are well apprised, that the smallest islets, those which are without mountains, collect and harbour the clouds. The decrement of heat is also different above the plains of Africa, and above the surface of the ocean*; and the strata of air, brought by the trade winds, cool in proportion as they advance towards the west. If the air has been extremely dry above the burning sands of the desert; it is very quickly saturated when it has entered into contact with the surface of the sea, or with the air that lies on this surface. It is easy to conceive, therefore, why the vapors become visible in the atmospherical strata, which, at a distance from the continent, have no longer the same temperature as when they began to be saturated with water. The considerable mass of a mountain, which rises in the midst of the Atlantic, is also an obstacle to the clouds, which are driven out to sea by the winds.

We waited long and impatiently the permission of the governor of the place to land. I employed this time in making the necessary observations for determining the longitude of the mole of Santa Cruz, and the dip of the needle. Berthoud's

* Obs. Ast. t. i, p. 126.

chronometer gave, for the first 18° 33′ 10″. This differs three or four minutes from the result of former observations by Fleurieu, Pingré, Borda, Vancouver, and La Peyrouse. M. Quenot nevertheless obtained 18° 33′ 36″, and the unfortunate Captain Bligh 18° 34′ 20″. The precision of my result was confirmed three years after, the voyage of the chevalier Krusenstern, who found Santa Cruz 16° 12′ 45″ west of Greenwich, and consequently 18° 33′ 0″ west of Paris. These data prove, that the longitudes Captain Cook assigned to Teneriffe and the Cape of Good Hope are much too far west *. The same navigator had found the magnetic dip, in 1799, 61° 52′. M. Bonpland and myself observed it at 62° 24′, a result conformable to that which was obtained in 1791 by M. de Rossel in the voyage of D'Entrecasteaux †. The variation of the needle differs several degrees, according to the place where the observation is made, at the Mole, or at several points to the north, along the shore. We must not be surprised at these variations in a place surrounded by volcanic rocks. I remarked with M. Gay-Lussac, that on the declivity of Vesuvius, and in the inside of its crater, the intensity of the mag-

* Galeano, Viage ad Magellanes, p. 8 : Krusenstern, Reise um die Welt, th. i, s. 78 : and my Obs. Astron. t. i, p. xxxvii, 27, and 33.

† Voyage à la Recherche de la Peyrouse, t. 2, p. 291.

netic forces is modified by the proximity of the lavas *.

After having undergone the fatigue of answering the numberless questions about political events put by persons who came to visit us on board, we landed. The boat was immediately sent back to the ship, lest the surf, which in this road is very dangerous, should drive it against the mole. The first object that met our view was a tall woman, of a very tawny complexion, and badly clothed, who was called the *capitana*. She was followed by several others, whose dress was not more becoming. They all earnestly requested permission to go on board the Pizarro, which was of course refused. In this port, so much frequented by Europeans, licentiousness bears the semblance of order. The *capitana* is a chief chosen by her companions, over whom she exercises great authority. She prevents whatever may be injurious to the service of the vessels; she engages the sailors to return on board at their stated hours. It is to her that the officers apply, when they fear that any of their crew conceal themselves with the intention of deserting.

On entering the streets of Santa Cruz, we felt a suffocating heat, though the thermometer was not above 25 degrees. Those who have for a long

* Mémoires de la Société d'Arcueil, t. i, p. 9.

time breathed the air of the sea suffer every time they land; not because this air contains more oxygen than the air on shore, as has been erroneously stated, but because it is less charged with those gazeous combinations*, which the animal and vegetable substances, and the mud resulting from their decomposition, pour into the atmosphere. Miasms that escape chemical analysis have a powerful effect on our organs, especially when these have not undergone for a long while the same kind of irritation.

Santa Cruz, the Annaza of the Guanches, is a neat town, with a population of 8000 souls. I was not struck with the excessive number of monks and secular ecclesiastics, which travellers have thought themselves under the necessity of finding in every country under the Spanish government: nor shall I stop to enter into the description of the churches; the library of the Dominicans, which contains scarcely a few hundred volumes; the mole, where the inhabitants assemble to inhale the freshness of the evening breeze; or the famed monument of marble of Carara, thirty feet high, dedicated to *our Lady of the Candelaria*, in memory of her miraculous appearance, in 1392, at Chimisay, near Guimar. The port of Santa Cruz may be considered as a great caravansary, on the road to America and the Indies. Every travel-

* Nouv. Espag. t. ii, p. 787.

ler, who writes the narrative of his adventures, begins by a description of Madeira and Teneriffe; and if in the natural history of these islands there yet remains as it were, an immense field untrod, we must admit, that the topography of the little towns of Funchal, Santa Cruz, Laguna, and Orotava, leaves scarcely any thing untold*.

The recommendation of the court of Madrid procured us in the Canaries, as in all the other Spanish possessions, the most satisfactory reception. The captain general gave us immediate permission to examine the island. Col. Armiaga, who commanded a regiment of infantry, received us into his house with kind hospitality. We could not cease admiring the banana, the papaw tree, the poinciana pulcherrima, and other plants, which we had hitherto seen only in hot houses, cultivated in his garden in the open air. The climate of the Canaries however is not warm enough to ripen the real *platano arton*, with triangular fruit from seven or eight inches long, and which, requiring a temperature of 24 centesimal degrees, does not flourish even in the Valley of Caraccas. The bananas of Teneriffe are those named

* Borda, Voy. de la Flore, t. i, p. 86. Vieyra, Noticias historicas. t. ii, p. 134. Bory de St. Vincent, Essai sur les Isles Fortunées, p. 230. Ledru, Voyage aux Isles de Ténériffe et de Porto-Rico, t. i, p. 37. Milbert, Voy. pitt. à l' Isle de Frrance, t. i, p. 9. Lord Macartney's Voyage, vol. i, p. 74.

by the Spanish planters *camburis* or *guincos*, and *dominicos*. The camburi, which suffers the least from the cold, is even cultivated with success at Malaga*; but the fruit which we see occasionally at Cadiz comes from the Canary islands by vessels, which make the passage in three or four days. In general, the musa, known by every people under the torrid zone, though hitherto never found in a wild state, has as great a variety of fruit as our apple and pear trees. These varieties †, which are confounded by the greater part of botanists, though they require a very different climate, are become permanent by long cultivation.

We went to herbalize in the evening towards the fort of Passo Alto, along the basaltic rocks that close the promontory of Naga. We were very little satisfied with our harvest, for the drought and dust had almost destroyed vegetation. The cacalia kleinia, the euphorbia canariensis, and several other succulent plants, which draw their nourishment from the air rather than the soil on which they grow, reminded us by their appearance, that this group of islands belongs to Africa, and even to the most arid part of that continent.

Though the captain of the ship had orders to

* The mean temperature of this town is only 18°.

† Nouv. Esp. t. ii, p. 362.

stop long enough at Teneriffe, to give us time to scale the summit of the Peak, if the snows did not prevent our ascent, we received notice, on account of the blockade of the English ships, not to hope a longer delay than that of four or five days. We consequently hastened our departure for the port of Orotava, which is situate on the western declivity of the volcano, where we were sure of finding guides. I could find no one at Santa Cruz, who had mounted the Peak, and I was not surprised at this. The most curious objects become less interesting, in proportion as they are placed nearer to us; and I have known inhabitants of Schaffhaussen, in Switzerland, who had never seen the fall of the Rhine but at a distance.

The 20th of June, before sunrise, we began our excursion by ascending to the Villa de Laguna, elevated 350 toises * above the port of Santa Cruz. We could not verify this estimation of the height, the surf not having permitted us to return on board during the night, to take our barometers and dipping needle. As we foresaw, that our expedition to the Peak would be very precipitate, we consoled ourselves easily with the idea of not exposing instruments, which were to serve us in countries less known by Europeans.

* This estimation is but an approximation. See the note at the end of the third chapter.

The road by which we ascended to Laguna is on the right of a torrent, or *baranco*, which in the rainy season forms fine cascades; it is narrow and tortuous. I have been assured since my return, that Mr. de Perlasca has laid out a new road, which will admit carriages. Near the town we met some white camels, which seemed to be very slightly laden. The chief employment of these animals is to transport merchandise from the customhouse to the warehouses of the merchants. They are generally laden with two chests of Havanna sugar, which together weigh 900 pounds; but this load may be augmented to thirteen hundred weight, or 52 arrobas of Castile. Camels are not plenty at Teneriffe; while they exist by thousands in the two isles of Lanzerota and Fortaventura; the climate and vegetation of these islands, placed nearer Africa, are more analogous to those of that continent. It is very extraordinary, that this useful animal, which breeds in South America, should be almost barren at Teneriffe. In the fertile district of Adexe only, where the plantations of the sugar cane are most considerable*, camels have sometimes been known to breed. These beasts of burden, as well as horses, were brought into the Canary islands in the fifteenth century by the Nor-

* They do not at present produce yearly above 300 quintals of moist sugar.

man conquerors. The Guanches were unacquainted with them; and this fact seems to be very well accounted for by the difficulty of transporting an animal of such bulk in frail canoes, without recurring to the necessity of considering the Guanches as a remnant of the people of the Atlantis, or a different race from that of the western Africans.

The hill, on which the town of San Christobal de la Laguna is built, belongs to the system of basaltic mountains, which, independant of the system of less ancient volcanic rocks, form a broad girdle around the peak of Teneriffe. The basalt on which we walked was of a darkish brown, compact, half decomposed, and exhaled, when breathed on, a clayey smell. We discovered hornblende, olivine *, and translucid pyroxenes †, with a perfectly lamellar fracture, of a tender olive green, and often crystallized in prisms of six planes. The first of these substances is extremely rare at Teneriffe; and I never found it in the lavas of Vesuvius; those of Etna alone contain it in abundance. Notwithstanding the great number of blocks, which we stopped to break, to the great regret of our guides, we could discover neither nepheline, nor leucite ‡, nor feldspath. This, which is so common in the basaltic lavas

* Peridot granuliforme. Hauy.

† Augit. Werner.

‡ Amphigène. Hauy.

of the island of Ischia, does not begin to appear at Teneriffe, till we approach the volcano. The rock of Laguna is not columnar, but divided into ledges of small thickness, and inclined to the east under an angle of 30 or 40 degrees. It has no where the appearance of a current of lava flowing from the sides of the peak. If the present volcano has given birth to these basaltes, we must suppose, that, like the substances which compose the Somma, at the back of Vesuvius, they are the effect of a submarine effusion, in which the liquid mass has formed real strata. A few bushy euphorbiums, the cacalia kleinia, and Indian figs (cactus), which are become wild in the Canary islands, as well as in the south of Europe and the whole continent of Africa, are the only plants we see on these arid rocks. The feet of our mules were slipping every moment on beds of stone, which were very steep. We nevertheless recognized the remains of an ancient pavement. In these colonies we discover at every step some traces of that activity, which the Spanish nation displayed in the 16th century.

As we approached Laguna, we felt the temperature of the atmosphere gradually decrease. This sensation is so much the more agreeable, as the air of Santa Cruz is very suffocating. As our organs are more affected by disagreeable impressions, the change of temperature becomes still

more sensible when we return from Laguna to the port: we seem then to be drawing near the mouth of a furnace. The same impression is felt, when, on the coast of Caraccas, we descend from the mountain of Avila to the port of La Guayra. According to the law of the decrement of heat, three hundred toises in height produce in this latitude only three or four degrees difference in temperature. The heat which overpowers the traveller on his entrance into Santa Cruz, or La Guayra, ought consequently to be attributed to the reverberation from the rocks, against which these towns are built.

The perpetual coolness, which is found at Laguna, is the reason why in the Canaries it is considered as a delightful abode. Situate in a small plain, surrounded by gardens, protected by a hill which is crowned by a wood of laurels, myrtle, and arbutus, the capital of Teneriffe is very beautifully placed. We should be mistaken, if, according to the account of some travellers, we believed it seated on the border of a lake. The rain sometimes forms a sheet of water of some extent; and the geologist, who beholds in every thing the past rather than the present state of nature, can have no doubt, but that the whole plain is a great basin dried up. Laguna, fallen from its opulence, since the lateral eruptions of the volcano have destroyed the port of Garachico, and Santa Cruz has become the centre of the commerce of this island,

contains only 9000 inhabitants, of whom nearly 400 are monks, divided among six convents. Some travellers have asserted, that half the population wore the ecclesiastic dress. The town is surrounded with a great number of windmills, which indicate the cultivation of wheat in these high countries. I shall observe on this occasion, that different kinds of grain were known to the Guanches. They called wheat at Teneriffe *tano*, at Lanzerota *triffa;* barley, in the grand Canary, bore the name of *aramotanoque*, and at Lanzerota that of *tamosen*. The flower of roasted barley *(gofio)* and goat's milk constituted the principal food of this nation, on the origin of which so many systematic fables have been built. These aliments are sufficient proofs, that the race of the Guanches belonged to the nations of the old continent, perhaps to those of Caucasus, and not like the rest of the Atlantides*, to the inhabitants of the New World; these, before the arrival of the Europeans, were unacquainted with corn, and milk, and cheese.

A great number of chapels, which the Spaniards call *ermitas*, encircle the town of Laguna. Shaded

* Without entering here into any discussion respecting the existence of the Atlantis, I shall cite the opinion of Diodorus Siculus, according to whom the Atlantides were ignorant of the use of corn, because they were separated from the rest of mankind before these gramina were cultivated. *Diod. Sicul.* t. III, p. 130, Wessel.

by trees of perpetual verdure, and placed on small eminences, these chapels add to the picturesque effect of the landscape. The interior side of the town is not equal to its external appearance. The houses are solidly built, but very antique, and the streets seem deserted. A botanist ought not to complain of the antiquity of the edifices. The roofs and walls are covered with Canary house-leek, and those elegant trichomanes, mentioned by every traveller. These plants are nourished by the frequent fogs.

Mr. Anderson, the naturalist in the third voyage of Captain Cook, advises the European physicians to send their sick to Teneriffe, undoubtedly not from those motives, which induce some practitioners to prefer the mineral waters that are at the greatest distance, but on account of the mildness of the temperature and equal climate of the Canaries. The ground on these islands rises in an amphitheatre, and presents simultaneously, as in Peru and Mexico, the temperature of every climate, from the heats of Africa to the cold of the higher Alps. Santa Cruz, the port of Orotava, the town of the same name, and that of Laguna, are four places, the mean temperatures of which form a descending series. In the south of Europe, the change of the seasons is still too perceptible, to offer the same advantages. Teneriffe on the contrary, situate as it were on the threshold of the tropics, though but a few days' sail from Spain,

shares in the beauties, which nature has lavished on the equinoctial regions. Vegetation here displays some of its fairest and most majestic forms in the banana and the palm-tree. He who is awake to the charms of nature finds in this delicious island remedies still more potent than the climate. No abode appeared to me more fitted to dissipate melancholy, and restore peace to the perturbed mind, than that of Teneriffe, or Madeira. These advantages are the effect not of the beauty of the site and the purity of the air alone; the moral feeling is no longer harrowed up by the view of slavery, the appearance of which is so revolting in the West Indies, and in every other place, whither European planters have conveyed what they call their civilization, and their industry.

In winter the climate of Laguna is extremely foggy, and the inhabitants often complain of the cold. A fall of snow however has never been seen, which may seem to indicate, that the mean temperature of this town must be above 18·7° (15° R.), that is to say, exceeding that of Naples. I do not lay this down as a rigorous conclusion; for in winter, the refrigeration of the clouds does not depend so much on the mean temperature of the whole year, as on the instantaneous diminution of heat, to which a district is exposed by its local situation. The mean temperature of the capital of Mexico, for instance, is only 16·8° (13·5° R.) nevertheless, in the space of a hundred years,

snow has fallen only once, while in the south of Europe, and in Africa, it snows in places where the mean temperature is above 19 degrees.

The vicinity of the sea renders the climate of Laguna more temperate in winter, than it would otherwise be on account of its elevation above the level of the ocean. I was even astonished to learn, that M. Broussonet had planted in the midst of this town, in the garden of the Marquis de Nava, the bread-fruit tree (artocarpus incisa), and cinnamon tree (laurus cinnamomum). These valuable productions of the South Sea and the East Indies are naturalized there as well as at Orotava. Does not this attempt prove, that the bread-fruit might flourish in Calabria, Sicily, and Grenada? The culture of the coffee tree has not equally succeeded at Laguna, though its fruit ripens at Teguesta, as well as between the port of Orotava and the village of St. Juan de la Rambla. It is probable, that some local circumstances, perhaps the nature of the soil, and the winds that prevail in the flowering season, are the cause of this phenomenon. In other regions, in the neighbourhood of Naples for instance, the coffee-tree produces abundantly, though the mean temperature scarcely rises above 18 centigrade degrees.

No person has ascertained, in the island of Teneriffe, the lowest height at which snow falls every year. This fact, easy of execution by barometrical measurements, has hitherto been generally

neglected under every zone; it is nevertheless highly interesting both to agriculture in the colonies and meteorology, and full as important as the measure of the limit of the perpetual snows. My observations furnished me with the data, which I shall record in the following table.

Northern latitude.	Lowest height at which the snow falls.		Inferior limit of the perpetual snows.		Difference of the two preceding columns.		Mean temperature.	
	toises.	metres	toises.	metres	toises.	metres	Cent.	Reau.
0°	2040	3976	2460	4794	420	818	27°	21·6°
20°	1550	3020	2360	4598	810	1578	24·5°	19·6°
40°	0	0	1540	3001	1540	3001	17°	13·6°

This table presents only the ordinary state of nature, that is to say, the phænomena as they are annually observed. Exceptions founded on particular local circumstances, exist. Thus it sometimes snows, though seldom, at Naples, at Lisbon, and even at Malaga, consequently as low as the 37th degree of latitude: and, as we have just observed, snow has been seen to fall at Mexico, the elevation of which is 1173 toises above the level of the Ocean. This phænomenon, which had not been seen for several centuries, took place on the day that the Jesuits were expelled, and was attributed by the people to this act of severity. A more striking exception was found in the climate of Valladolid, the capital of the province of Mechoacan. According to my

measures, this height of the town, situate in 19° 42′ of latitude, is only a thousand toises: and yet, a few years before our arrival in New Spain, the streets were covered with snow for some hours.

Snow has been seen to fall also at Teneriffe, in a place lying above Esperanza de la Laguna, very near the town of this name, in the gardens of which the artocarpus flourishes. This extraordinary fact was confirmed to M. Broussonet by very aged persons. The erica arborea, the myrica faya, and the arbutus callicarpa *, did not suffer from this snow; but it destroyed all the swine in the open air. This observation is interesting to vegetable physiology. In hot countries, the plants are so vigorous, that cold is less injurious to them, provided it be of short duration. I have seen the banana cultivated in the island of Cuba, in places where the thermometer descends to seven centesimal degrees, and sometimes very near the freezing point. In Italy and Spain the orange and date trees do not perish, though the cold during the night is two degrees below the freezing point. In general it is remarked by cultivators, that the trees which grow in a fertile soil are less delicate, and consequently less affected by great changes in the

* This fine arbutus, imported by M. Broussonet, is very different from the arbutus laurifolia, with which it has been confounded, and which belongs to North America.

temperature, than those which grow in land that affords but little nutriment*.

In order to pass from the town of Laguna to the port of Orotava and the western coast of Teneriffe, we cross at first a hilly region covered with black and argillaceous earth, in which are found some small crystals of pyroxene. The waters most probably detach these crystals from the neighbouring rocks, as at Frascati near Rome. Unhappily, strata of ferruginous earth conceal the soil from the researches of the geologist. It is only in some ravines, that we find columnar basaltes, somewhat curved, and above them very recent brecciæ, resembling volcanic tufa. These brecciæ contain fragments of the same basaltes which they cover; and it is asserted, that marine petrifactions are observed in them. The same phænomenon occurs in the Vicentin, near Montechio Maggiore.

The valley of Tacoronte is the entrance into this charming country, of which travellers of every nation have spoken with rapturous enthu-

* The mulberries, cultivated in the meagre and sandy soils of countries bordering on the Baltic Sea, are examples of this feebleness of organization. The late frosts do more injury to them, than to the mulberries of Piedmont. In Italy a cold of 5° below the freezing point does not destroy robust orange trees. According to Mr. Galesio, these trees, less tender than the lemon and bergamot orange trees, freeze only at ten centesimal degrees below the freezing point.

siasm. Under the torrid zone I found sites, where nature is more majestic, and richer in the display of organic forms; but after having traversed the banks of the Orinoco, the Cordilleras of Peru, and the most beautiful valleys of Mexico, I own, that I have never beheld a prospect more varied, more attractive, more harmonious in the distribution of the masses of verdure and of rocks.

The seacoast is lined with date and cocoa trees. Groups of musa, as the country rises, form a pleasing contrast with the dragon-tree, the trunks of which have been justly compared to the tortuous form of the serpent. The declivities are covered with vines, which throw their branches over towering poles. Orange-trees loaded with flowers, myrtles, and cypress trees entwine the chapels reared to devotion on the isolated hills. The divisions of property are marked by hedges formed of the agave and the cactus. An innumerable quantity of cryptogamous plants, among which ferns are the most predominant, cover the walls, moistened by small springs of limpid water. In winter, when the volcano is buried under ice and snow, this district enjoys perpetual spring. In summer, as the day declines, the breezes from the sea come loaded with delicious coolness. The population of this coast is very considerable; and it appears to be still greater than it is, because the houses and gardens are more distant from each other, which adds to the picturesque beauty of the situation.

Unhappily the real welfare of the inhabitants does not correspond with the exertions of their industry, or with the advantages which nature has lavished on this spot. The farmers are not proprietors; the fruits of their labour belong to the nobles, and those feudal institutions, which, for so long a time, spread misery throughout Europe, still weigh heavily on the happiness of the people of the Canary Islands.

From Tegueste and Tacoronte to the village of St. Juan de la Rambla, which is celebrated for its excellent malmsey, the rising hills are cultivated like a garden. I might compare them to the environs of Capua and Valentia, if the western part of Teneriffe was not infinitely more beautiful on account of the proximity of the Peak, which presents on every side a varied landscape. The view of this mountain is interesting not merely from its gigantic mass; it fills the mind, by carrying it back to the mysterious source of its volcanic agency. For thousands of years, no flames or light have been perceived on the summit of the Piton, nevertheless enormous lateral eruptions, the last of which took place in 1798, are proofs of the activity of a fire still far from being extinguished. There is also something, that leaves a melancholy impression on the mind on seeing a crater in the centre of a fertile and well cultivated country. The history of the globe instructs us, that volcanoes destroy what they have been a long series of ages in creating.

Islands, which the action of submarine fires has raised above the waters, are decked by degrees in rich and smiling verdure; but these new abodes are often laid waste by the renewed action of the same power, which caused them to emerge from the bottom of the ocean. Perhaps those islets, which are now but heaps of scoriæ and volcanic ashes, were once as fertile as the hills of Tacoronte and Sauzal. Happy the country, where man has no distrust of the soil on which he lives!

Pursuing our course to the port of Orotava, we passed the smiling hamlets of Matanza and Vittoria. These names are mingled together in all the Spanish colonies, and form a disagreeable contrast with the feelings of peace and tranquillity, which those countries inspire. *Matanza* signifies butchery, or carnage; and the word alone recalls the price, at which victory has been purchased. In the New World, it generally indicates the defeat of the natives; at Teneriffe, the village of Matanza was built in a place* where the Spaniards were conquered by those same Guanches, who soon after were sold as slaves in the markets of Europe.

Before we reached Orotava, we visited a botanic garden at a small distance from the port. We there found M. Le Gros, the French vice-consul, who had often scaled the summit of the Peak, and who served us as an excellent guide. He was

* The ancient Acantejo.

accompanying Captain Baudin in a voyage to the West Indies, which has largely contributed to enrich the garden of plants at Paris. A dreadful tempest, of which M. Le Dru has given an account in the narrative of his voyage to Porto Rico, forced the vessel to put into Teneriffe; where M. Le Gros was led by the beauty of the spot to settle. It was he who gave the learned of Europe the first accurate ideas of the great lateral eruptions of the Peak, which has been very improperly called the explosion of the volcano of Chahorra *.

The establishment of a botanical garden at Teneriffe is a very happy idea, on account of the double influence, which it may have on the progress of botany, and on the introduction of useful plants into Europe. For the first idea of it we are indebted to the Marquis de Nava †, whose name deserves to be recorded with that of M. Poivre, and who, habitually engaged in doing good, has made a noble use of his fortune. He undertook, at an enormous expense, to level the hill of Durasno, which now rises as an amphitheatre, and which was begun to be planted in 1795. The marquis thought, that the Canary Islands, from the mildness of their climate and geographical position, afforded the most suitable place for naturalising the productions of the two Indies, and serving as a

* The 8th of June, 1798.

† Marquis de Villanueva del Prado.

repository to habituate the plants gradually to the colder temperature of the south of Europe. In fact, the plants of Asia, Africa, and South America, may easily be brought to Orotava; and in order to introduce the bark-tree * into Sicily, Portugal, or Grenada, it should be first planted at Durasno, or at Laguna, and the shoots of this tree may afterwards be transported into Europe from the Canaries. In happier times, when maritime wars shall no longer interrupt communication, the garden of Teneriffe may become extremely useful with respect to the great number of plants, which are sent from the Indies to Europe; for ere they reach our coasts, they often perish, on account of the length of the passage, during which they inhale an air impregnated with salt water. These plants would meet at Orotava with the care and climate necessary to their preservation. The keeping of the botanic garden having become every year more expensive, the Marquis de Nava has ceded it to the government. We found in it a well-informed

* I speak of the species of bark-tree (cinchona), which at Peru, and in the kingdom of New Grenada, flourish on the back of the Cordilleras, at the height of between 1000 and 1500 toises, in places where the thermometer is between nine and ten degrees during the day, and from three to four during the night. The oranged bark-tree (cinchona lancifolia) is much less tender than the red bark-tree (c. oblongifolia). See the Memoir on the Forests of the bark-tree, which I published in 1807, in the *Magasin der Naturkunde*, B. i, p. 118.

gardener, who had been brought up under Mr. Aiton, director of the royal garden at Kew. The earth is raised in terraces, and watered by a natural spring. It has a view of the island of Palma, which appears like a castle in the midst of the ocean. We found this establishment but little stocked with plants, vacant places of genera were filled up with tickets, the names of which seemed to have been taken by chance, as they were found in the systema vegetabilium of Linnæus. This distribution of plants, after the classes of the sexual system, which is unhappily the case in several gardens in Europe, is very hostile to their cultivation. At Durasno, the protei, the psidium, the jambos, the chirimoya of Peru *, sensitive plants, and heliconias, flourish in the open air. We gathered the ripened seeds of several beautiful species of glycine from New Holland, which the governor of Cumana, Mr. Emparan, successfully cultivated, and which since grow wild on the coasts of South America.

We arrived very late at the port of Orotava †, if we may give the name of port to a road, in which the vessels are obliged to put to sea whenever the winds blow violently from the north-west. It is impossible to speak of Orotava, without recalling

* Annona cherimolia. Lamarck.

† Puerto de la Cruz. The only fine port of the Canary Islands is that of St. Sebastien, in the isle of Gomera.

to the remembrance of the scientific world the name of Mr. Cologan, whose house at all times was open to travellers of every nation. Several members of this respectable family have been educated at London and at Paris. Don Bernardo Cologan unites the most ardent zeal for the good of his country to various parts of solid instruction. We are agreeably surprised to find, in a group of islands near the coasts of Africa, that urbanity, that taste for knowledge, that love of the arts, which is thought to belong exclusively to a small part of Europe.

We could have wished to have sojourned for some time in Mr. Cologan's house, and visited with him the charming scenery of St. Juan de la Rambla and of Rialexo de Abaxo*. But on a voyage such as that we had undertaken, the present is but little enjoyed. Continually haunted by the fear of not executing the designs of the morrow, we live in perpetual uneasiness. Persons who are passionately fond of nature and the arts feel the same sensations, when they travel through Switzerland and Italy. Enabled to see but a small portion of the objects which allure them, they are disturbed in their enjoyments by the restraints they impose on themselves at every step.

On the morning of the 21st of June, we were

* The last of these two villages is placed at the foot of the lofty mountain of Tygayga.

already on the road for the summit of the volcano. M. Le Gros, whose attentions were unwearied, M. Lalande, secretary of the French Consulate at Santa Cruz, and the English gardener at Durasno, shared in the fatigues of this excursion. The day was not very fine, and the summit of the Peak, which is generally visible at Orotava from sunrise till ten o'clock, was covered with thick clouds. There is only one path to the volcano, by the *Villa de Orotava, the Plain of Spartium*, and the *Malpais*; it is this which was taken by father Feuillée, Borda, La Billardiere, Barrow, and all late travellers, who have made but a short stay at Teneriffe. In an excursion to the Peak, as well as in those which are commonly made in the valley of Chamouni and to the top of Etna, where we are forced to follow the guide, we see almost nothing but what has been already seen and described by former travellers.

We were agreeably surprised by the contrast between the vegetation of this part of Teneriffe, and that of the environs of Santa Cruz. Under the influence of a cool and humid climate, the ground was covered with beautiful verdure; while on the road from Santa Cruz to Laguna the plants exhibited nothing but pods emptied of their seeds. Near the port of Santa Cruz, the strength of the vegetation is an obstacle to geological researches. We went on foot over two small hills, which rise in the form of bells. Observations made at Ve-

suvius, and in Auvergne, lead us to think, that these paps owe their origin to lateral eruptions of the great volcano. The hill called *Montannita de la Villa* seems indeed to have already emitted lavas; and according to the tradition of the Guanches this eruption took place in 1430. Colonel Franqui assured Borda, that the place is still to be seen whence the melted matter issued; and that the ashes, which covered the ground adjacent, were not yet productive*. Wherever the rock appears, we discovered basaltic amygdaloid† covered with hardened clay‡, which contains *rapilli*, or fragments of pumice stone. This last formation resembles the tufas of Pausilippo, and the strata of Puzzolana, which I found in the valley of Quito, at the foot of the Volcano of Pichincha.

* This fact is taken from a manuscript now at Paris, at the depôt of the Charts of the Marine. It bears the title of *Résumé des Operations de la Campagne de la Boussole* (in 1776) *pour determiner les Positions géographiques des Côtes d'Espagne & de Portugal sur l'Ocean, d'une Partie des Côtes occidentales de l'Afrique, & des Iles Canaries, par le Chevalier de Borda.* This is the manuscript of which M. Fleurieu speaks in the notes, which he has added to the Voyage of Marchand, vol. 2, p. 11, and which M. de Borda had communicated to me previous to my departure. As I have extracted some important observations from it, which have never been published, I shall cite it in this work under the title of *Manuscript du Dépôt.*

† Basaltartiger mandelstein. Werner.

‡ Bimstein-conglomerat. W.

The amygdaloid has very long pores, like the superior strata of the lavas of Vesuvius, arising probably from the action of an elastic fluid forcing its way through the matter in fusion. Notwithstanding these analogies, I must here repeat, that in all the low region of the Peak of Teneriffe, on the side of Orotava, I have met with no flow of lavas, no current, the limits of which were strongly marked. Torrents and inundations change the surface of the globe, and when a great number of currents of lava meet and spread over a plain, as I have seen at Vesuvius, in the *Atrio dei Cavalli*, they seem to be confounded together, and wear the appearance of real strata.

The *villa de Orotava* has a pleasant aspect at a distance, from the great abundance of waters which run through the principal streets. The spring of *Agua mansa*, collected in two large reservoirs, turns several mills, and is afterward discharged among the vineyards of the adjacent hills. The climate is still more refreshing at the *villa* than at the port of La Cruz, from the influence of the breeze, which blows strong after ten in the morning. The water, which has been dissolved in the air at a higher temperature, frequently precipitates itself, and renders the climate very foggy. The villa is nearly 160 toises (312 metres) above the surface of the ocean, consequently 200 toises less than the ground on which Laguna is

built; it is observed also, that the same kind of plants flower a month later in this latter place.

Orotava, the ancient Taoro of the Guanches, is placed on a very steep declivity; the streets seem deserted; the houses, solidly built, but of a gloomy appearance, belong almost all to the nobility, who are accused of being extremely haughty, and who give themselves the pompous title of the *doze casas* (the twelve houses). We passed along a lofty aqueduct, lined with a great number of fine ferns; and visited several gardens, in which the fruit trees of the north of Europe are mingled with orange trees, pomegranate, and date trees. We were assured, that these last were as little productive here as on the coasts of Cumana. Although we were acquainted, from the narratives of so many travellers, with the dragon-tree of the garden of Mr. Franqui, we were not the less struck with its enormous magnitude. We were told, that the trunk of this tree, which is mentioned in several very ancient documents as marking the boundaries of a field, was as gigantic in the fifteenth century, as it is at the present moment. Its height appeared to us to be about 50 or 60 feet; its circumference near the roots is 45 feet. We could not measure higher, but Sir George Staunton found, that, 10 feet from the ground, the diameter of the trunk is still 12 English feet; which corresponds perfectly with the assertion of Borda, who found its mean circumference 33 feet

8 inches, French measure. The trunk is divided into a great number of branches, which rise in the form of a candelabrum, and are terminated by tufts of leaves, like the yucca which adorns the valley of Mexico. It is this division, which gives it a very different appearance from that of the palm-tree*.

Among organised beings, this tree is undoubtedly, together with the adansonia or baobab of Senegal, one of the oldest inhabitants of our globe. The baobabs are of still greater dimensions than the dragon-tree of Orotava. There are some, which near the root measure 34 feet in diameter, though their total height is only from 50 to 60 feet †. But we should observe, that the adansonia,

* I have given, in the Picturesque Atlas which accompanies this narrative, (Pl. 58 of the folio Atlas), the figure of the dragon tree of Franqui, from a sketch made in 1776 by M. D'Ozonne, at the time of the expedition of Messrs. de Borda and Varela.

† Adanson is surprised, that the baobabs have not been cited by other travellers. I find, in the collection of Grynæus, that Aloysio Cadamosto speaks of the great age of those monstrous trees, which he saw in 1504, and of which he says very truly, "*eminentia altitudinis non quadrat magnitudini.*" Cadam. Navig. chap. 42. At Senegal, and near Praya, in the islands of Cape Verd, Messrs. Adanson and Staunton remarked adansoniæ, the trunks of which were from 56 to 60 feet in circumference. Voy. au Sénégal, t. 1, p. 54. The baobab 34 feet in diameter was seen by Mr. Golberry, in the valley of the two Gagnacks. Fragmens d'un Voy. en Afrique, t. 2, p. 92.

like the ochroma, and all the plants of the family of bombax, grow much more rapidly* than the dracœna, the vegetation of which is very slow. That in Mr. Franqui's garden bears still every year both flowers and fruit. Its aspect feelingly recalls to mind "that eternal youth† of nature," which is an inexhaustible source of motion and of life.

The dracœna, which is seen only in cultivated spots in the Canary islands, at Madeira, and Porto Santo, offers a curious phænomenon with respect to the migration of plants. It has never been found in a wild state on the continent of Africa‡: the East Indies is its real country. By

* It is the same with the plane-tree (platanus occidentalis) which M. Michaux measured at Marietta, on the banks of the Ohio, and which, at twenty feet from the ground, was 15·7 feet in diameter (Voy. à l'Ouest des Monts Alleghany, 1804, p. 93). The taxus, chesnut, oak, plane-tree, cupressus disticha, bombax, mimosa, cæsalpinia, hymenea, and dracœna, appear to me to be the plants, which, in different climates, offer specimens of the most extraordinary growth. An oak, discovered together with some Gallic helmets in 1809, in the turf pits of the department of the Somme, near the village of Yseux, seven leagues from Abbeville, was about the same size as the dragon tree of Orotava. According to a memoir by M. Traullée, the trunk of this oak was 14 feet in diameter.

† Aristot. de Longit. Vitæ, cap. 6, (ed. Casaub. p. 442.)

‡ Mr. Schousboe, in his Flora of Morocco (*Danske Videns-kabens-Selskabs Skrivter*, B. v, p. 4) does not even mention it among the cultivated plants, while he speaks of the cactus,

what means has this tree been transplanted to Teneriffe, where it is no way common? does its existence prove, that, at some very distant epocha, the Guanches had connections with other nations originally from Asia?

On leaving Orotava, a narrow and stony pathway led us across a beautiful forest of chesnut trees, *el monte de Castannos*, to a site which is covered with brambles, some species of laurels, and arborescent heaths. The trunks of the last grow to an extraordinary size; and the flowers with which they are loaded form an agreeable contrast, during a great part of the year, with the hypericum canariense, which is very abundant at this height. We stopped to take in our pro-

the agave, and the yucca. The form of the dragon-tree is exhibited in several species of the genus dracæna, at the Cape of Good Hope, in China, and in New Zealand; but in the New World it is replaced by the form of the yucca; for the dracæna borealis of Aiton is a convallaria, of which it has all the appearance. The astringent juice, known in commerce by the name of dragon's blood, is, according to the inquiries we made on the spot, the produce of several American plants, which do not belong to the same genus, and of which some are liannes*. At Laguna, toothpicks steeped in the juice of the dragon-tree are made in the nunneries, and are much extolled as highly useful for the preservation of the gums.

* A general term used for climbing plants in the French West India islands. Ed.

vision of water under a solitary firtree. This station is known in the country by the name of *Pino del Dornajito;* its height, according to the barometrical measurement of M. de Borda * is 522 toises; and it commands a magnificent prospect of the sea, and the whole of the northern part of the island. Near Pino del Dornajito, a little on the right of the pathway, is a copious spring of water, into which we plunged the thermometer, which fell to 15·4°. At a hundred toises distance from this spring is another equally limpid. If we admit, that these waters indicate nearly the mean heat of the place whence they issue, we find the absolute elevation of the station 520 toises, supposing † the mean tem-

* *Manuscrit du Dépôt, 7me cahier,* p. 15. I calculated the heights, which I mention in the text, according to the formula of M. Laplace, and the coefficient of Mr. Ramond: In the manuscript, we find "516 toises, according to the tables of De Luc." We must not confound the Pino del Dornajito with the station of the *Pino de la Mericnda,* cited by Eden and father Feuillée; and elevated 800 toises above the level of the Ocean. This last station is between the Caravela and the Portillo. See the note on the whole o these measures, at the end of the *Journal de Route.*

† As a proof, that these objections are founded on accurate observations, I will here observe, that the mean temperature of the low regions of the isle of Madeira, which is a little to the north of Teneriffe is 20·4°; and that my observations, made under the torrid zone, allow for the decrement of caloric 98 toises to each centesimal degree; while the results taken by M. Ramond, under the temperate zone, in la-

perature of the coast to be 21°, and allowing one degree for the decrement of caloric corresponding under this zone to 93 toises. We should not be surprised, if this spring remained a little below the heat of the air, since it is probably formed in some more elevated part of the peak, and communicates perhaps even with the small subterranean glaciers, of which we shall speak hereafter. The accordance which we have just observed between the barometrical and thermometrical measures is so much the more striking, because in general, as I have elsewhere explained*, in mountainous countries, with steep declivities, the springs indicate too great a decrement of caloric, because they unite small currents of water, which filter at different heights, and their temperature is consequently the mean between the temperature of these currents. The spring of Dornajito has considerable reputation in the country;

titude 45°, give 84 toises. From these extremes it follows, that the height of the Dornajito is either 548 toises, or 470 toises. M. de Borda found in 1776 the temperature of the air near the spring 5° colder than at the port of Orotava, which seems to prove, that the decrement of 93 toises, which I have supposed, is not too slow. *Phil. Trans.* vol. xlvii, p. 358. Ramond, Mém. sur la Formule barom. p. 189.

* *Astron. Obs.* vol. i, p. 132. Thus in the Blue Mountains of Jamaica Mr Hunter found springs constantly colder than they ought to have been, according to the height at which they issued.

and was the only one known, at the time of my excursion, on the road which leads to the summit of the volcano. The formation of springs demands a certain regularity in the direction and inclination of the strata. On a volcanic soil, porous and splintered rocks absorb the rain waters, and lead them to considerable depths. Hence arises that aridity observed in the greater part of the Canary islands, notwithstanding the considerable height of their mountains, and the mass of clouds which navigators behold incessantly piled over this archipelago.

From Pino del Dornajito to the crater of the volcano we continued to ascend without crossing a single valley; for the small ravines *(barancos)* do not merit this name. To the eyes of the geologist the whole of the isle of Teneriffe is but one monntain, the almost elliptical base of which is prolonged to the north-east, and in which we distinguish several systems of volcanic rocks formed at different epochas. The *Chahorra,* or *Montana Colorada,* and the *Urca,* considered in the country as insulated volcanoes, are only little hills abutting on the Peak, and marking its pyramidal form. The great volcano, the lateral eruptions of which have given birth to vast promontories, is not however precisely in the centre of the island, and this peculiarity of structure appears less surprising, if we recollect, as a learn-

ed mineralogist has observed *, that it is not perhaps the small crater of the Piton, which has acted the principal part in the revolutions undergone by the isle of Teneriffe.

Above the region of arborescent heaths, called *Monte Verde*, is the region of the ferns. No where, under the temperate zone, have I seen such an abundance of the pteris, blechnum, aud asplenium; yet none of these plants have the stateliness of the arborescent ferns, which at the height of five or six hundred toises form the principal ornament of equinoctial America. The root of the pteris aquilina serves the inhabitants of Palma and Gomera for food; they grind it to powder, and mix with it a small quantity of barley-meal. This composition, when boiled, is called *gofio;* the use of so homely an aliment is a proof of the extreme penury of the lower order of people in the Canary islands.

Monte Verde is intersected by several small and very arid ravines (cannadas), and the region of ferns is succeeded by a wood of juniper trees and firs, which has suffered greatly from the violence of the hurricanes. In this place, mentioned by some travellers under the name of Caravela, Mr. Eden † asserts that he saw little flames, which,

* M. Cordier.

† This visit took place in 1715. Phil. Trans. vol. xxix, p. 317. Carabela is the name of a vessel with latin sails.

according to the doctrine of the naturalists of his time, he attributes to sulphurous exhalations that take fire of themselves. We continued to ascend, till we came to the rock of La Gayta and to Portillo; traversing this narrow passage between two basaltic hills, we entered the great plain of Spartium*. At the time of the voyage of La Peyrouse, M. Manneron had taken the levels of the Peak, from the port of Orotava to this elevated plain near 1400 toises above the level of the sea; but the want of water, and the misconduct of the guides, had prevented him from taking the levels to the top of the volcano. The results of this operation, which was two thirds finished, unfortunately were not sent to Europe, and this work is still to be recommenced from the seacoast.

We spent two hours and a half in crossing the Llano del Retama, which appears like an immense sea of sand. Notwithstanding the elevation of this site, the centigrade thermometer rose in the shade, toward sunset, to 13·8°, or 3·7° higher than toward noon at Monte Verde. This augmentation of heat could be attributed only to the reverberation from the ground, and the extent of the plain. We suffered much from the suffocating

The pines of the peak formerly were used as masts of vessels, and the royal navy cut its wood *(cortes de madera)* on the Monte Verde.

* Los Llanos del Retama.

dust of the pumice stone, in which we were continually enveloped. In the midst of this plain are tufts of the *retama*, which is the spartium nubigenum of Aiton. This charming shrub, which M. de Martiniere* wished to introduce into Languedoc, where firewood is very scarce, grows to the height of nine feet; it is loaded with odoriferous flowers, with which the goat hunters, that we met in our road, had decorated their hats. The goats of the Peak, which are of a deep brown, are reckoned delicious food; they browse on the spartium, and have run wild in the deserts from time immemorial. They have even been transported to Madeira, where they are preferred to the goats of Europe.

As far as the rock of Gayta, or the entrance of the extensive Llano del Retama, the Peak of Teneriffe is covered with beautiful vegetation: nothing bears the mark of recent devastation. We might have imagined ourselves scaling the side of some volcano, the fire of which had been extinguished as remotely as that of Monte Cavo, near Rome; but scarcely had we reached the plain covered with pumice stone, when the landscape changed its aspect, and at every step we met with large blocks of obsidian thrown out by the volcano. Every thing here speaks perfect solitude. A few

* One of the botanists who perished in the expedition of La Peyrouse.

goats and rabbits only bound across the plain. The barren region of the Peak is nine square leagues; and as the lower regions viewed from this point shrink in the prospect, the island appears an immense heap of torrefied matter, hemmed round by a scanty border of vegetation.

From the region of the spartium nubigenum we passed through narrow defiles, and small ravines hollowed very anciently by the torrents, first to a more elevated plain *(el Monton de Trigo)*, then to the place where we intended to pass the night. This station, which is more than 1530 toises above the coast, bears the name of the English Halt *(Estancia de los Ingleses*)*, no doubt because English travellers were those, who formerly visited the Peak most frequently. Two inclined rocks form a kind of cavern, that affords a shelter from the winds. This point, already higher than the summit of the Canigou, can be reached on the backs of mules; and here ends the expedition of numbers of travellers, who on leaving Orotava

* This denomination was already in use at the beginning of the last century. Mr. Eden, who corrupts all Spanish words, as do the greater part of travellers in our own times, calls it the *Stancha:* it is the *Station des Rochers* of M. Borda, as is proved by the barometrical heights there observed. These heights were in 1803, according to M. Cordier, 19 inches 9·5 lines; and in 1776, according to Messrs. Borda and Varela, 19 inches 9·8 lines; the barometer at Orotava keeping within nearly a line at the same height.

had hoped to have ascended to the brink of the crater. Though in the midst of summer, and under the bright sky of Africa, we suffered from the cold during the night. The thermometer descended as low as to five degrees. Our guides made a large fire with the dry branches of retama. Having neither tents nor cloaks, we lay down on a heap of burnt rocks, and were singularly incommoded by the flame and smoke, which the wind drove towards us. We had attempted to form a kind of screen with cloths tied together, but our enclosure took fire, which we did not perceive, till the greater part had been consumed by the flames. We had never passed a night on a point so elevated, and did not then conjecture, that on the ridge of the Cordilleras we should one day inhabit towns higher than the summit of the volcano we were to scale on the morrow. As the temperature diminished, the Peak became covered with thick clouds. The approach of night interrupts the play of the ascending current, which, during the day, rises from the plains towards the high regions of the atmosphere; and the air, in cooling, loses its capacity of suspending water. A strong northerly wind chased the clouds; the moon at intervals, shooting across the vapors, exposed its disk on a firmament of the darkest blue; and the view of the volcano threw a majestic character over the nocturnal scenery. Sometimes the Peak was

entirely hidden from our eyes by the fog, at others, it broke upon us in terrific nearness; and, like an enormous pyramid, threw its shadow over the clouds rolling beneath our feet.

Towards three in the morning, by the sombrous light of a few fir torches, we began our expedition for the summit of the Piton. We scaled the volcano on the north east, where the declivities are extremely steep; and we came, after two hours toil, to a small plain, which, on account of its isolated situation, bears the name of *Alta Vista.* It is the station also of the *neveros,* those natives, whose occupation it is to collect ice and snow, which they sell in the neighbouring towns. Their mules, better practised in climbing mountains than those hired by travellers, reach *Alta Vista,* and the *neveros* are obliged to transport the snow to this place on their backs. Above this point the *Malpays* begins, a term by which is designated here, as well as in Mexico, Peru, and every other country subject to volcanoes, a ground destitute of vegetable mould, and covered with fragments of lavas.

We turned towards the right to examine the *Cavern of Ice,* which is at 1728 toises, consequently below the limit of the perennial snows under this zone. It is probable, that the cold which reigns in this cavern is owing to the same causes, which perpetuate the ice in the crevices of

Mount Jura, and the Apennines, and on which the opinions of naturalists are still much divided *. This natural ice-house of the Peak has nevertheless none of those perpendicular openings, which give emission to the warm air, while the cold air remains undisturbed at the bottom. It seems that the ice is preserved in it on account of its mass, and because its melting is retarded by the cold, which is the consequence of quick evaporation. This small subterraneous glacier is situate in a region, the mean temperature of which is probably not under three degrees; and it is not, like the true glaciers of the Alps, fed by the snow waters that flow from the summits of the mountains. During winter, the cavern is filled with ice and snow; and as the rays of the sun do not penetrate beyond the mouth, the heats of summer are not sufficient to empty the reservoir. The existence of a natural ice house depends, consequently, rather on the quantity of snow which enters it in winter, and the small influence of the warm winds that blow in

* Saussure, Voyage dans les Alpes, §. 1406—1414. Prevost, du Calorique rayonnant, p. 409—422. In the greater part of the *cellars of ice*, for instance that of St. George, between Niort and Rolle, a thin layer of limpid ice forms itself in summer on the walls of the calcareous rock. Mr. Pictet observed, that at this epocha the thermometer does not descend, in the air of the cellar, below two or three degrees, so that we must attribute the congelation to a local and very rapid evaporation.

summer, than on the absolute elevation of the cavity, and the mean temperature of the layer of air in which it is situate. The air contained in the bowels of a mountain is not easily displaced, as is proved by Monte-Testaceo, at Rome, the temperature of which is so different from that of the surrounding atmosphere. We shall see in the course of this work, that on Chimborazo enormous heaps of ice are found covered with sand, and, in the same manner as at the Peak, far below the inferior limit of the perpetual snows.

It was near the Cellar of Ice *(Cueva del Hielo)*, that, in the voyage of La Péyrouse, Messrs. Lamanon and Mongès made their experiments on the temperature of boiling water. These naturalists found it 88·7°, the barometer being at nineteen inches one line. In the kingdom of New Grenada, at the chapel of Guadaloupe, near Santa-Fe de Bogota, I have seen water boil at 89·9°, under a pressure of 19 inches 1·9 lines. At Tambores, in the province of Popayan, Mr. Caldas found the heat of boiling water 89·5°, the barometer being at 18 inches 11·6 lines. These results might lead us to suspect, that, in the experiment of M. Lamanon, the water had not reached the maximum of its temperature *.

The dawn appeared when we left the cavern of

* A calculation, made according to the tables of Mr. Dalton, gives 89·4° for La Cueva, and 89·5° for Guadaloupe.

ice. We observed, during the twilight, a phænomenon which is not unusual on high mountains, but which the position of the volcano, that we were scaling, rendered very striking. A layer of white and fleecy clouds concealed from us the sight of the ocean, and the lower region of the island. This layer did not appear above 800 toises high; the clouds were so uniformly spread, and kept so perfect a level, that they wore the appearance of a vast plain covered with snow. The colossal pyramid of the Peak, the volcanic summits of Lanzerota, of Fortaventura, and the isle of Palma, were like rocks amidst this vast sea of vapors, and their black tints were in fine contrast with the whiteness of the clouds.

While we were climbing over the broken lavas of the Malpays, we perceived a very curious optical phænomenon, which lasted eight minutes. We thought we saw on the east side small rockets thrown into the air. Luminous points, about seven or eight degrees above the horizon, appeared first to move in a vertical direction; but their motion was gradually changed into a real horizontal oscillation. Our fellow travellers, our guides even, were astonished at this phænomenon, without our having made any remark on it to them. We thought at first sight, that these luminous points, which floated in the air, indicated some new eruption of the great volcano of Lanzerota. We recollected, that Bouguer and La Con-

danine, in scaling the volcano of Pichincha, were witnesses of the eruption of Cotopaxi; but the illusion soon ceased, and we found, that the luminous points were the images of several stars magnified by the vapors. These images remained motionless at intervals, they then seemed to rise perpendicularly, descended sideways, and returned to the point whence they had departed. This motion lasted one or two seconds. Though we had no exact means of measuring the greatness of the lateral shifting, we did not less distinctly observe the path of the luminous point. It did not appear double from an effect of looming *(mirage)*, and left no trace of light behind. Bringing, with the telescope of a small sextant by Troughton, the stars into contact with the lofty summit of a mountain in Lanzerota, I observed, that the oscillation was constantly directed towards the same point, that is to say, towards the part of the horizon where the disk of the sun was to appear; and that, making allowance for the motion of the star in its declination, the image returned always to the same place. These appearances of lateral refraction ceased long before daylight had rendered the stars quite invisible. I have faithfully related what we saw during the twilight, without undertaking to explain this extraordinary phænomenon, of which I published an account in Baron Zach's Astronomical Journal, twelve years ago. The motion of the vesicular vapors, caused by the

rising of the sun; the mingling of several layers of air, the temperature and density of which were very different, no doubt contributed to produce an apparent movement of the stars in the horizontal direction. We see something similar in the strong undulations of the solar disk, when it cuts the horizon; but these undulations seldom exceed twenty seconds, while the lateral motion of the stars, observed at the Peak, at more than 1800 toises, was easily distinguished by the sight alone, and seemed to exceed all that we have thought it possible to consider hitherto as the effect of the refraction of the light of the stars. On the top of the Andes, at Antisana, I was present at sunrise, and passed the whole night at 2100 toises, without noting any appearance resembling this phænomenon.

I was anxious to make an exact observation of the instant of sunrising at an elevation so considerable as that we had reached on the Peak of Teneriffe. No traveller, furnished with instruments, had as yet taken such an observation. I had a telescope, and a chronometer, of which I knew the great exactness. In the part where the sun was to appear, the horizon was free from vapors. We perceived the upper limb at $4^h\ 48'\ 55''$ apparent time, and what is very remarkable, the first luminous point of the disk was found immediately in contact with the limit of the horizon; consequently we saw the true horizon, that is to say, a part

of the sea farther than 43 leagues. It is proved by calculation, that, under the same parallel in the plain, the rising would have begun at 5 1′ 50·4″ or 11′ 51·3″ later than at the height of the Peak. The difference observed was 12′ 55″, which arose no doubt from the uncertainty of the refraction for a zenith distance, of which observations are wanting*.

We were surprised at the extreme slowness, with which the lower limb of the sun seemed to detach itself from the horizon. This limb was not visible till 4^h 56′ 56″. The disk of the sun, much flattened, was well defined; during the ascent, there was neither double image nor lengthening of the lower part. The duration† of the sun's

* In this calculation we have supposed, that for an apparent zenith distance of 91° 54′, there are 57′ 7″ of refraction. The rising sun appears sooner at the Peak of Teneriffe than in the plain by the time that it takes to pass through an arc of 1° 54′. The greatness of the arc is augmented only 41′ for the summit of Chimborazo. The ancients had such exaggerated ideas of the acceleration of the rising of the sun on the top of high mountains, that they admitted, that this luminary was visible on Mount Athos three hours sooner than on the coast of the Egean sea (*Strabo edit. Almeloven*, lib. 7, p. 510): yet Mount Athos, according to M. Delambre, is only 713 toises high (*Choiseul Gouffier, Voy. pitt. de la Grece*, t. 2, p. 140.)

† The apparent duration was 8′ 1″ instead of 2′ 41″. Though my journals contain near eighty observations of the rising and setting of the sun, made either during the voyage,

rising being triple that which we might have expected in this latitude, we must suppose, that a fog bank, very uniformly extended, concealed the true horizon, and followed the sun in its ascent. Notwithstanding the libration of the stars*, which we had observed toward the east, we could not attribute the slowness of the rising to an extraordinary refraction of the rays occasioned by the horizon of the sea; for it is precisely at the rising of the sun, as Le Gentil daily observed at Pondicherry, and as I have several times remarked at Cumana, that the horizon sinks, on account of the elevation of temperature in the stratum of the air† which lies immediately over the surface of the ocean.

The road, which we were obliged to find across the Malpays, was extremely fatiguing. The ascent is steep, and the blocks of lava rolled from beneath our feet. I can compare this part of the road

or on the coasts, I have never perceived any sensible retardation.

* A celebrated astronomer, Baron Zach, (*Mon. Corres.* 1800, p. 396) has compared this phænomenon of an apparent libration of the stars to that described in the Georgics (lib. 1, v. 365). But this passage relates only to the falling stars, which the ancients, as well as our mariners, considered as a prognostic of wind. The Latin poet appears to have imitated the verses of Aratus. (*Diosem.* v. 926, *edit. Buhle* 1, p. 206, *Lucret.* II, v. 143.)

† *Biot, Rech. sur les Refractions extraordinaires,* p. 218, 223, and 228.

only to the *Moraine* of the Alps, or that mass of pebbly stones, which we find at the lower extremity of the glaciers; at the Peak, the lava, broken into sharp pieces, leaves hollows, in which we risked falling up to our waists. Unfortunately the laziness of our guides contributed to render this ascent more painful. Unlike those of the valley of Chamouni, or the nimble footed Guanches, who could, it is asserted, seize the rabbit or wild goat in its course, our Canarian guides were models of the phlegmatic: they wished to persuade us the preceding evening, not to go beyond the station of the rocks: every ten minutes they sat down to repose themselves, and when unobserved threw away the specimens of obsidian and pumice-stone, which we had carefully collected. We discovered at length, that none of them had ever yet visited the summit of the volcano.

After three hours march, we reached, at the extremity of the Malpays, a small plain, called la Rambleta, from the centre of which the Piton, or Sugar-loaf, takes its rise. On the side toward Orotava the mountain resembles those pyramids with steps, that are found at Fayoum and in Mexico; for the elevated plains of Retama and Rambleta form two stages, the first of which is four times higher than the second. If we suppose the total height of the Peak to be 1904 toises, the Rambleta is 1820 toises above the level of the sea. Here are found those spiracles, which are called

by the natives the Nostrils of the Peak *. Watery and heated vapors issue at intervals from several crevices in the ground, and the thermometer rose to 43·2°: M. Labillardiere had found the temperature of these vapors, eight years before us, 53·7°; a difference which does not perhaps prove so much a diminution of activity in the volcano, as a local change in the heating of its internal surface. The vapors have no smell, and seem to be pure water. A short time before the great eruption of Mount Vesuvius, in 1805, M. Gay-Lussac and myself had observed, that water, under the form of vapor, in the interior of the crater, did not redden paper dipped in sirup of violets. I cannot, however, admit the bold hypothesis of several naturalists, according to which the Nostrils of the Peak are to be considered as the mouths of an immense apparatus of distillation, the lower part of which is placed below the level of the ocean. Since the time that volcanoes have been carefully studied, and that the love of the marvellous has been less observed in works on geology, very well founded doubts have been raised respecting these direct and constant communications between the waters of the sea, and the focus of the volcanic fire †. We may find a very simple

* Narices del Pico.

† This question has been examined with much sagacity by Mr. Breislak, in his Introduzzione alla Geologia, t. 2, p. 302, 323, 347. Cotopaxi and Popocatepetl, which I have seen

explanation of a phænomenon, that has in it nothing very surprising. The Peak is covered with snow during part of the year; we ourselves found it still so in the plain of Rambleta. Messrs. O'Donnel and Armstrong discovered in 1806 a very abundant spring in the Malpays, a hundred toises above the cavern of ice, which is perhaps fed partly by this spring. Every thing, consequently, leads us to presume, that the Peak of Teneriffe, like the volcanoes of the Andes, and those of the island of Manilla, contains within itself great cavities, which are filled with atmospherical water, owing merely to filtration. The aqueous vapors, which are exhaled by the nostrils and crevices of the crater, are only those same waters heated by the interior surfaces down which they flow.

We had yet to scale the steepest part of the mountain, the Piton, which forms the summit. The slope of this small cone, covered with volcanic ashes, and fragments of pumice stone, is so steep, that it would have been almost impossible to reach the top, had we not ascended by an old

ejecting smoke and ashes, in 1804, are farther from the South Sea and the Gulf of the Antilles, than Grenoble is from the Mediterranean, and Orleans from the Atlantic. We must not consider the fact as merely accidental, that we have not yet discovered an active volcano more than 40 leagues distant from the ocean; but I consider the hypothesis, that the waters of the sea are absorbed, distilled, and decomposed by volcanoes, as very doubtful.

current of lava, the wrecks of which have resisted the ravages of time. These wrecks form a wall of scorious rocks, which stretches itself into the midst of the loose ashes. We ascended the Piton by grasping these half decomposed scoriæ, the sharp edges of which remained often in our hands. We employed nearly half an hour to scale a hill, the perpendicular height of which is scarcely ninety toises. Vesuvius *, three times lower than

* According to the barometrial measurements, which Mr. Leopold von Buch, M. Gay-Lussac, and myself, took in 1805, the height of Vesuvius is diminished on the south-west side since the year 1794, where a part of the cone fell in, two days after the ashes had been ejected. Saussure found Vesuvius, in 1773, 609 toises high, at a time when the brinks of the whole of the crater were nearly of the same height. Sir George Shuckburgh measured, in 1776, a hill placed in the midst of the crater; it was 615 toises in height. This hill scarcely existed at the time of Saussure's journey, and disappeared in the eruption of 1779. It was the eruption of 1794, which caused the great inequality of the two brinks of the crater; this unevenness was 71 toises in 1805. Mr. Poli found Vesuvius, a short time before, 606 toises in height. Sir G. Shuckburgh reckoned the highest point of the Somma, called *del Vitello*, 584 toises. This observation is not very accordant with the height, which M. Gay-Lussac assigns to the highest brink of the crater; for, in 1805, this part of the brink seemed to have the same elevation as the *Punta del Vitello*. I know not where Shuckburgh placed his instrument at the foot of the cone of ashes; for he states this point at only 316 toises of absolute height. The following is a table of the measures made in very calm weather, with a portable cistern-barometer by Ramsden.

the Peak of Teneriffe, is terminated by a cone of

I. Measures taken by M. Gay-Lussac alone.

July 1805.	Places.	Barom. in lines.	Therm. of Reaum.	Height above lev. of the sea in toises	
The 28th at 7 in the evening	At the seaside	338·5	22°	. .	These heights, and those that follow, were calculated after the formula of M. Laplace.
at 10 in the evening	At the hermit of S Salvador's	316·3	18°	302	
The 29th at 2 in the morning	Idem	316 4	19°	. .	
at 3	At the lower brink of the crater in the road . .	300·0	15°	. .	The temperature of the mercury is supposed to be equal to that of the air, and the height of the apartment of the hermit 3 toises above the small plain of Saint Salvador. The correspondent heights of the barometer and of the thermometer have been interpolated.
at 5	Idem	300·5	15°	530	
at ½ past 5	At the loftiest brink of the crater	295·4	14·4°	606	
at ½ past 7	At the beginning of the cone of ashes	311 5	18°	375	
at ½ past 11	At the hermit's	317·1	22°		

II. Measures taken by Messrs. Gay Lussac, Buch, and Humboldt.

August, 1805.	Places.	Barom. in lines.	Therm. of Reaum.	Height abo. level of the sea in toises	
The 4th at 5 in the morning	Small elevated plain of the hermitage	315·4	17°	301	The barometer at Portici was 7 toises above the level of the Mediterranean; at the lower brink of the crater, the instrument was placed lower than the 29th of July.
at 45 minutes past 5	Beginning of the cone .	311 0	17 5°	365	
at 7	Hill in the centre of the crater	298 5	15°	542	
at 8	Lowest brink of the crater	300·7	15·5°	511	
at ½ past 3	Portici	337 0	16°		
at 2 in the afternoon	Idem	337·0	24°		

ashes almost three times higher, but with a more accessible and easy slope. Of all the volcanoes which I have visited, that of Jorullo, in Mexico, is the only one, that is more difficult to climb than the Peak, because the whole mountain is covered with loose ashes.

When the Sugar loaf (el Piton) is covered with snow, as it is in the beginning of winter, the steepness of its declivity may be very dangerous to the traveller. M. Le Gros showed us the place, where Captain Baudin had nearly perished, at the time of his voyage to the isle of Trinidad. This officer had the courage to undertake, in company with the naturalists Advenier, Mauger, and Riedlé, an excursion to the top of the volcano towards the end of December, 1797. Having reached half the height of the cone, he had a fall, and rolled down as far as the small plain of Rambleta; happily a heap of lava, covered with snow, hindered him from rolling farther with ac-

M. de la Jumélière asserts, in a paper printed in the Moniteur, that he found, by geometrical measurement, the height of Vesuvius 597 toises. It were to be wished, that he had published the detail of his operations. Our measurements give 606 toises (1181 metres) for the most elevated brink of the crater; 535 toises (1042 metres) for the lower brink; 370 toises (721 metres) for the foot of the cone of ashes; and 302 toises (588 metres) for the hermitage of San Salvador. Such was the state of Vesuvius a short time before the eruption in the year 1805, in which the lava made a breach in the brink of the crater on the side of Torre del Greco.

celerated velocity. I have been told, that in Switzerland a traveller was suffocated by rolling down the declivity of the Col de Balme, over the compact turf of the Alps.

When we gained the summit of the Piton, we were surprised to find scarcely room enough to seat ourselves conveniently. We were stopped by a small circular wall of porphyritic lava, with base of pitchstone, which concealed from us the view of the crater*. The west wind blew with such violence that we could scarcely stand. It was eight in the morning, and we were frozen with the cold, though the thermometer kept a little above the freezing point. For a long time we had been accustomed to a very high temperature, and the dry wind increased the feeling of cold, because it carried off every moment the small atmosphere of warm and humid air, which was formed around us from the effect of cutaneous perspiration.

The brink of the crater of the Peak bears no resemblance to those of the greater part of the other volcanoes which I have visited: for instance, the craters of Vesuvius, Jorullo, and Pichincha. In these the Piton preserves its conic figure to the very summit: the whole of their declivity is inclined the same number of degrees, and uni-

* *La Caldera*, or the *caldron* of the Peak, a denomination which recals to mind the *Oules* of the Pyrenees. Ramond, Voy. au Mont-Perdu, p. 235.

formly covered with a layer of pumice stone very minutely divided; when we reach the top of these volcanoes, nothing obstructs the view of the bottom of the crater. The Peak of Teneriffe, and Cotopaxi, on the contrary, are of very different construction. At their summit a circular wall surrounds the crater; which wall, at a distance, has the appearance of a small cylinder placed on a truncated cone. On Cotopaxi* this peculiar construction is visible to the naked eye at more than 2000 toises distance; and no person has ever reached the crater of this volcano. On the Peak of Teneriffe, the wall, which surrounds the crater like a parapet, is so high, that it would be impossible to reach the Caldera, if on the eastern side there was not a breach, which seems to have been the effect of a flowing of very old lava. We descended through this breach toward the bottom of the funnel, the figure of which is elliptic. Its greater axis has a direction from north-west to south-east, nearly N. 35° W. The greatest breadth of the mouth appeared to us to be 300 feet, the smallest 200 feet. These numbers agree very nearly with the measures of Messrs. Verguin, Varela, and Borda†, for these travellers assign 40 and 30 toises to the two axes‡.

* Picturesque Atlas, folio, pl. 10.

† Voy. de la Flore, t. i, p. 94. Manusc. du Dépôt de la Marine, cah. 7, p. 15. Voy. de Marchand, t. ii, p. 11.

‡ M. Cordier, who visited the top of the Peak four years

It is easy to conceive, that the size of a crater does not depend solely on the height and mass of the mountain, of which it forms the principal air vent. This opening is indeed seldom in direct ratio with the intensity of the volcanic fire, or with the activity of the volcano. At Vesuvius, which is but a hill compared with the Peak of Teneriffe, the diameter of the crater is five times greater. When we reflect, that very lofty volcanoes throw out less matter by their summits, than by lateral openings, we should be led to think, that the lower the volcanoes are, their force and activity being the same, the more considerable ought to be their craters. In fact, there are immense volcanoes in the Andes, which have but very small openings; and we might establish it as a geological principle, that the most colossal mountains have craters of little extent at the summits, if the Cordilleras did not offer many instances * to the contrary. I shall have occasion, in the progress of this work, to cite a number of facts, which will throw some light on what may be called the external structure of volcanoes. This structure is as varied

after me, estimates the greater axis at 66 toises (Journ. de Phys. t. lvii, p. 62). Lamanon thinks it 50 toises. But Mr. O' Donnel gives the crater a circumference of 236 toises (550 *varas*).

* The great volcanoes of Cotopaxi and Rucupichincha have craters, the diameter of which, according to my measurements, exceed 400 and 700 toises.

as the volcanic phænomena themselves; and in order to raise ourselves to geological conceptions worthy of the greatness of nature, we must set aside the idea, that all volcanoes are formed after the model of Vesuvius, Stromboli, and Etna.

The external edges of the Caldera are almost perpendicular. Their appearance is somewhat like the Somma, seen from the Atrio del Cavallo. We descended to the bottom of the crater on a train of broken lava, from the eastern breach of the enclosure. The heat was perceptible only in a few crevices, which gave vent to aqueous vapours with a peculiar buzzing noise. Some of these funnels or crevices are on the outside of the enclosure, on the external brink of the parapet that surrounds the crater. We plunged the thermometer into them, and saw it rise rapidly to 68 and 75 degrees. It no doubt indicated a higher temperature, but we could not observe the instrument till we had drawn it up, lest we should burn our hands. M. Cordier found several crevices, the heat of which was that of boiling water. It might be thought, that these vapours, which are emitted in gusts, contain muriatic or sulphurous acid; but when condensed, they have no particular taste; and experiments, which several naturalists* have made with reagents,

* Voyage de La Pérouse, t. iii, p. 2.

prove, that the chimneys of the Peak exhale only pure water. This phænomenon, analogous to what I observed in the crater of Jorullo, deserves the more attention, as muriatic acid abounds in the greater part of volcanoes, and as M. Vauquelin has discovered it even in the porphyritic lavas of Sarcouy in Auvergne.

I sketched on the spot a view * of the interior edge of the crater, as it presented itself in the descent by the eastern break. Nothing is more striking than the manner, in which these strata of lavas are piled on one another, exhibiting the sinuosities of the calcareous rock of the higher Alps. These enormous ledges, sometimes horizontal, at others inclined and undulating, remind us of the ancient fluidity of the whole mass, and the combination of several deranging causes, which determined the direction of each flow. The top of the circular wall exhibits those grotesque ramifications, which we find in coak. The northern edge is more elevated; towards the south-west, the enclosure is considerably sunk, and an enormous mass of scorious lava seems glued to the extremity of the brink. On the west the rock is perforated; and a large opening gives a view of the horizon of the sea. The force of the elastic vapours formed perhaps this natural aperture, at the moment of some inundation of lava thrown out from the crater.

* Picturesque Atlas, folio, Pl. 54.

The inside of this funnel indicates a volcano, which for thousands of years has vomited no fire but by its sides. This assertion is not founded on the absence of great openings, which might be expected in the bottom of the Caldera. Those naturalists, who have studied nature on the spot, know, that several volcanoes, in the intervals of an eruption, appear filled up, and almost extinguished; but that in these same mountains, the crater of the volcano exhibits layers of scoriæ, rough, sonorous, and shining; with hillocks and intumescences, caused by the action of the elastic vapours, cones of broken scoriæ, and ashes, which cover the funnels. None of these phænomena characterise the crater of the Peak of Teneriffe; its bottom has not remained in the state which follows the end of an eruption. From the lapse of time, and the action of the vapors, the inside walls are detached, and have covered the basin with great blocks of lithoid lavas.

We reached the bottom of the Caldera without danger. In a volcano, the activity of which is principally directed towards the summit, such as Vesuvius, the depth of the crater varies before and after each eruption; but at the Peak of Teneriffe the depth appears to have remained the same for a long time. Eden, in 1715, estimated it at 115 feet; Cordier, in 1803, at 110 feet. Judging by mere inspection, I should have thought the funnel of still less depth. Its present state is that

of a solfatara; and it is rather an object of curious investigation, than of tremendous aspect. The majesty of the site consists in its elevation above the level of the ocean, in the profound solitude of these lofty regions, and the immense space over which the eye ranges from the summit of the mountain.

The wall of compact lava, which forms the enclosure of the Caldera, is snow white at its surface. The same colour prevails in the inside of the solfatara of Puzzuoli. When we break these lavas, which might be taken at some distance for calcareous stone, we find in them a blackish brown nucleus. Porphry with basis of pitch stone is whitened externally by the slow action of the vapors of sulphurous acid gas. These vapors rise in abundance; and, what is remarkable enough, through crevices which seem to have no communication with the apertures that emit aqueous vapors. We may be convinced of the presence of the sulphurous acid, by examining the fine crystals of sulphur, which are every where found in the crevices of the lava. This acid, combined with the water with which the soil is impregnated, is transformed into sulphuric acid by contact with the oxygen of the atmosphere. In general, the humidity in the crater of the Peak is more to be feared than the heat; and they who seat themselves for a while on the ground find their clothes corroded. The porphyritic lavas are affected by

the action of the sulphuric acid: the alumin, magnesia, soda, and metallic oxids, gradually disappear; and often nothing remains but the silex, which unites in mammillary plates, like opal. These siliceous concretions*, which M. Cordier first made known, are similar to those found in the Isle of Ischia, in the extinguished volcanoes of Santa Fiora, and in the Solfatara of Puzzuoli †. It is not easy to form an idea of the origin of these incrustations. The aqueous vapours, discharged through great spiracles, do not contain alkali in solution, like the waters of the Geyser, in Iceland ‡. Perhaps the soda contained in the lavas of the Peak acts an important part in the formation of these depositions of silex. There may exist in the crater small crevices, the vapors of which are not of the same nature as those on which travellers, employed at the same moment in a great number of objects, have made experiments.

Seated on the northern brink of the crater, I dug a hole of some inches depth; the thermometer placed in this hole rose rapidly to 42°. Hence

* *Opalartiger kieselsinter.* The siliceous *gurh* of the volcanoes of the Isle of France contains, according to Klaproth, 0·72 silex, and 0·21 water; and thus comes near to opal, which Karsten considers as a hydrated silex. *Miner. Tabellen*, 1800, p. 70.

† Breislak, Introduzzione alla Geologia, t. 2, p. 238.

‡ Black, in Philos. Transact. 1794, p. 24.

we may conclude what must be the heat, that reigns in this solfatara at the depth of thirty or forty fathoms. The sulphur reduced into vapour is condensed into fine crystals, which however are not equal in size to those M. Dolomieu brought from Sicily*. They are semidiaphanous octaedrons, with very brilliant surfaces, and of a conchoidal fracture. These masses, which will one day perhaps be objects of commerce, are constantly bedewed with sulphurous acid. I had the imprudence to wrap up a few, in order to preserve them, but I soon discovered, that the acid had consumed not only the paper which contained them, but a part also of my mineralogical journal. The heat of the vapors, which issue from the crevices of the Caldera, is not sufficiently great, to combine the sulphur, while in a state of minute division, with the oxygen of the atmospheric air; and after the experiment which I have just cited on the temperature of the soil, we may presume, that the sulphurous acid is formed at a certain depth†, in cavities to which the external air has free access.

* These crystals were four or five inches in length. Drée, Cat. d'un Musée minéral. p. 21.

† An observer, in general very exact, Mr. Breislack, asserts (Geologia, t. 2, p. 232), that the muriatic acid always predominates in the vapours of Vesuvius. This assertion is contrary to what M. Gay-Lussac and myself observed, before the great eruption of 1805, and while the lava was issuing

The vapors of heated water, which act on the fragments of lava scattered about on the Caldera, reduce certain parts of it to a state of paste. On examining, after I had reached America, those earthy and friable masses, I found crystals of sulphat of alumin. Messrs. Davy and Gay-Lussac* have already made the ingenious remark, that two bodies highly inflammable, the metals of soda and potash, have probably an important part in the action of a volcano; now the potash necessary to the formation of alum is found not only in feldspar, mica, pumice stone, and augit, but also in obsidians †. This last substance is very common at Teneriffe, where it forms the basis of the tephrinic lava ‡. These analogies between the Peak of Teneriffe and the Solfatara of Puzzuoli, would no doubt appear more numerous, if the former were more accessible, and had been frequently visited by naturalists.

An expedition to the summit of the volcano of

from the crater. The smell of the sulphurous acid, so easy to distinguish, was perceptible at a great distance; and when the volcano threw out scoriæ, the smell was mingled with that of petroleum.

* Davy, on the Decomposition of fixed Alkalies, Phil. Trans. 1808, P. 1, p. 44.

† Collet Descotils, in the Ann. de Chimie, t. 53, p. 260. See Klaproth, Beitrage, B. 5, p. 159, 162, and 166.

‡ Laméthiere, Minéralogie, t. 2, p. 533; and Journal de Physique, 1806, p. 192.

Teneriffe is interesting, not solely on account of the great number of phænomena which are the objects of scientific research; it has still greater attractions from the picturesque beauties, which it lays open to those who are feelingly alive to the majesty of nature. It is a difficult task, to describe those sensations, which act with so much the more force as they have something undefined, produced by the immensity of the space as well as by the greatness, the novelty, and the multitude of the objects, amidst which we find ourselves transported. When a traveller attempts to furnish descriptions of the loftiest summits of the Globe, the cataracts of the great rivers, the tortuous vallies of the Andes, he is exposed to the danger of fatiguing his readers by the monotonous expression of his admiration. It appears to me more conformable to the plan, which I have proposed to myself in this narrative, to indicate the peculiar character that distinguishes each zone, we exhibit with more clearness the physiognomy of the landscape, in proportion as we endeavour to sketch its individual features, to compare them with each other, and discover by this kind of analysis the sources of those enjoyments, which are offered us by the great picture of nature.

Travellers have learnt by experience, that views from the summits of very lofty mountains are neither so beautiful, picturesque, nor varied, as those from heights which do not exceed that of Vesuvius, Rigi, and the Puy-de-Dôme. Colossal mountains, such

as Chimborazo, Antisana, or Mount Rose, compose so large a mass, that the plains covered with rich vegetation are seen only in the immensity of distance, where a blue and vapory tint is uniformly spread over the landscape. The Peak of Teneriffe, from its slender form and local position, unites the advantages of less lofty summits to those which arise from very great heights. We not only discover from its top a vast expanse of sea, but we see also the forests of Teneriffe, and the inhabited parts of the coasts, in a proximity fitted to produce the most beautiful contrasts of form and colour. We might say, that the volcano crushes with its mass the little isle which serves as its basis, and shoots up from the bosom of the waters to a height three times loftier than the region where the clouds float in the summer. If its crater, half extinguished for ages past, shot forth flakes of fire like that of Stromboli in the Æolian Islands, the Peak of Teneriffe, resembling a lighthouse, would furnish a direction to the mariner in a circuit of more than 260 leagues.

When seated on the external edge of the crater, we turned our eyes towards the north-west, where the coasts are decked with villages and hamlets. At our feet, masses of vapour, constantly driven by the winds, afforded us the most variable spectacle. A uniform stratum of clouds, the same as we have just described, and which separated us from the lower regions of the island, had been

pierced in several places by the effect of the small currents of air, which the earth, heated by the sun, began to send towards us. The port of Orotava, its vessels at anchor, the gardens and the vineyards which encircle the town, exhibited themselves through an opening which seemed to enlarge every instant. From the summit of these solitary regions our eyes hovered over an inhabited world; we enjoyed the striking contrast between the bare sides of the Peak, its steep declivities covered with scoriæ, its elevated plains destitute of vegetation, and the smiling aspect of the cultured country beneath; we beheld the plants divided by zones, as the temperature of the atmosphere diminished with the height of the site. Below the Piton, lichens begin to cover the scorious lava with lustered surface: a violet *, akin to the viola decumbens, rises on the slope of the volcano at 1740 toises of height; it takes the lead not only of the other herbaceous plants, but even of the gramina, which, in the Alps and on the ridge of the Cordilleras, form close neighbourhood with the plants of the family of cryptogamia. Tufts of retama, loaded with flowers, make gay the vallies hollowed out by the torrents, and which are encumbered with the effects of the lateral eruptions; below the spartium, or retama, lies the region of ferns, bordered by the

* Viola cheiranthifolia. See our equinoctial plants, vol. i, p. 111, Pl. 32.

tract of the arborescent heaths. Forests of laurel, rhamnus, and arbutus divide the ericas from the rising grounds planted with vines and fruit trees. A rich carpet of verdure extends from the plain of spartium, and the zone of the alpine plants even to the group of the date trees and the musa, at the feet of which the ocean appears to roll. I here pass slightly over the principal features of this botanical chart, as I shall enter hereafter into some farther details respecting the geography of the plants of the Isle of Teneriffe.

The seeming proximity, in which, from the summit of the Peak, we behold the hamlets, the vineyards, and gardens on the coast, is increased by the prodigious transparency of the atmosphere. Notwithstanding the great distance, we distinguished not only the houses, the sails of the vessels, and the trunks of trees, our eyes dwelt on the rich vegetation of the plains, enamelled with the most vivid colouring. These phænomena are owing not only to the height of the site, but to the peculiar modifications of the air in warm climates. Under every zone, an object placed on a level with the sea, and viewed in a horizontal direction, appears less luminous, than when seen from the top of a mountain, where vapors arrive across strata of air of decreasing density. Differences equally striking are produced by the influence of climates; the surface of a lake or large river is less resplendent, when we see it at an equal distance, from the top

of the higher Alps of Switzerland, than when we view it from the summit of the Cordilleras of Peru or Mexico. In proportion as the air is pure and serene, the solution of the vapours becomes more perfect, and the light loses less in its passage. When from the coast of the South Sea we reach the elevated plain of Quito, or that of Antisana, we are struck for some days at the nearness at which we think we see objects which are seven or eight leagues distant. The Peak of Teyde has not the advantge of being situate in the equinoctial region; but the dryness of the columns of air which rise perpetually above the neighbouring plains of Africa, and which the eastern winds bring with rapidity, gives the atmosphere of the Canary Islands a transparency, which surpasses not only that of the air of Naples and Sicily, but perhaps also the purity of the sky of Quito and Peru. This transparency may be regarded as one of the chief causes of the beauty of the landscape under the torrid zone; it is this which heightens the splendor of the vegetable coloring, and contributes to the magical effect of their harmonies and their contrasts. If a mass of light, which circulates about objects, fatigues the external senses during a part of the day, the inhabitant of the southern climates has his compensations in moral enjoyments. A lucid clearness in the conceptions, a serenity of mind, correspond with the transparency of the surrounding atmosphere. We feel these impres-

sions without overstepping the limits of Europe. I appeal to travellers who have visited countries rendered famous by prodigies of the imagination and the arts, the favored climates of Italy and Greece.

We prolonged in vain our stay on the summit of the Peak, to wait the moment when we might enjoy the view of the whole of the Archipelago of the Fortunate islands *. We discovered Palma, Gomera, and the Great Canary, at our feet. The mountains of Lanzerota, free from vapors at sunrise, were soon enveloped in thick clouds. On a supposition only of an ordinary refraction, the eye takes in, in calm weather, from the summit of the volcano, a surface of the globe of 5700 square leagues, equal to a fourth of the surface of Spain. The question has often been agitated, if it were possible to perceive the coast of Africa from the top of this colossal pyramid; but the nearest parts of this coast are still farther from Teneriffe than 2° 49′, or 56 leagues. The visual ray of the horizon from the Peak being 1° 57′, Cape Bojador can be seen only on the supposition of its height being 200 toises above the level of the ocean. We

* Of all the small islands of the Canaries, the *Rock of the East* is the only one, which cannot be seen, even in fine weather, from the top of the Peak. Its distance is 3° 5′, while that of the Salvage is only 2° 1′. The isle of Madeira, distant 4° 29′, would be visible, if its mountains were more than 3000 toises high.

are absolutely ignorant of the height of the Black Mountains near Cape Bojador, as well as that of the Peak, called by navigators *Pennon grande*, farther to the south of this promontory. If the summit of the volcano of Teneriffe was more accessible, we should observe without doubt, with certain winds, the effects of an extraordinary refraction. In looking over what the Spanish and Portuguese authors relate respecting the existence of the fabulous isle of San Borondon, or Antilia, we find, that it is particularly the humid wind of the west-south-west, which produces in these latitudes the phænomena of the mirage. We shall not however admit with Mr. Vieyra, "that the play of the terrestrial refractions* may render visible to the inhabitants of the Canaries the islands of Cape Verd, and even the Apalachian Mountains of America."

The cold, which we felt on the top of the Peak, was very considerable for the season. The centi-

* "La refraction da para todo." Noticias historicas, t. 1, p. 105. We have already stated, that the American fruits, frequently thrown by the sea on the coasts of the isle of Ferro and Gomera, were formerly attributed to the plants of the island of San Borondon. This land, said by the people to be governed by an archbishop and six bishops, and which Father Feijoo believed to be the image of the isle of Ferro, reflected on a fog bank, was ceded in the 16th century, by the king of Portugal, to Lewis Perdigon, at the time the latter was preparing to make the conquest of it.

grade thermometer*, at a distance from the ground, and from the apertures that emitted the hot vapors, descended in the shade to 2·7°. The wind was west, and consequently opposite to that which brings to Teneriffe, during a great part of the year, the warm air, that rises above the burning desert of Africa. As the temperature of the atmosphere, observed at the port of Orotava by Mr. Savagi, was 22·8°, the decrement of caloric was one degree every 94 toises. This result perfectly corresponds with those obtained by Lamanon and Saussure† on the summits of the Peak and Etna, though in very different seasons. The tall slender form of these mountains facilitates the means of comparing the temperature of two strata of the atmosphere, which are nearly in the same perpendicular plane; and under this point of view the observations made in an excursion to the volcano of Teneriffe resemble those of an ascent in a balloon. We must nevertheless remark, that the ocean, on account of its transparency and eva-

* Messrs. O'Donnel and Armstrong observed the 2d of August, 1806, at eight in the morning, on the top of the Peak, the thermometer in the shade at 13·8°, and in the sun at 20·5°. Difference or *power of the sun* 6 7 centesimal degrees.

† The observations of Lamanon give 99 toises for each degree of the centigrade thermometer, though the temperature of the Piton differed 9° from that which we observed. At Etna the decrement observed by Saussure was 91 toises.

poration, reflects less caloric than the plains into the upper regions of the air; the summits also which are surrounded by the sea are colder in the summer, than the mountains which rise from a continent; but this circumstance has very little influence on the decrement of the atmospherical heat, the temperature of the low regions being equally diminished by the proximity of the ocean.

It is not the same with respect to the influence exercised by the direction of the wind, and the rapidity of the ascending current; the latter sometimes increases in an astonishing manner the temperature of the loftiest mountains. I have seen the thermometer rise, on the slope of the volcano of Antisana, in the kingdom of Quito, to 19°, when we were 2837 toises high. M. Labillardière* has seen it remain, on the edge of the crater of the Peak of Teneriffe, at 18·7°, though he had used every possible precaution to avoid the effect of accidental causes. The temperature of the road of Santa Cruz being then at 28°, the difference between the air of the coast and on the summit of the Peak was 9·3°, instead of 20°, which corresponds to a decrement of caloric of 94 toises to each degree. I find in the Journal of the Expedition of d'Entrecasteaux, that at this period the wind at Santa Cruz was south-south-east. This same wind blew perhaps more impetuously

* Voyage à la Recherche de La Pérouse, Vol. 1, p. 23; Vol. 2, p. 65.

in the higher regions of the atmosphere, and forced back, in an oblique direction, the hot air of the neighbouring continent towards the summit of the Piton. Besides, the visit of M. Labillardière took place on the 17th of October, 1791; and, in the Alps of Switzerland, we have observed, that the difference of temperature between the mountains and the plains is considerably less in autumn, than in summer. All these variations * of the rapidity, with which caloric decreases, have their influence on the measures taken by the barometer, only in as much as the decrement is not uniform in the intermediate strata, and as it differs from the arithmetical or harmonic

* I shall here bring into one point of view the whole of the thermometrical observations made at the Peak of Teneriffe, and which are proper to determine the number of toises, that correspond to a lowering of a centigrade degree:

1° Borda (month of September.)
To the Pino de Dornajito, 104 toises (morning);
To the Station of the Rocks, 107 toises (evening);
To the natural icehouse, 105 toises (morning);
To the foot of the Piton, 151 toises (morning);
To the top of the Peak, 137 toises (morning);

2° Lamanon (month of August),
To the top, 99 toises (morning);

3° Cordier (month of April),
To the Station of the Rocks, 122 toises (evening);
To the top, 115 toises (morning);

4° Our Voyage (month of June),
To the top, 94 toises.

progression, which is presumed in the formulæ employed.

We could not withdraw our eyes, on the summit of the Peak, from beholding the color of the azure vault of the sky. Its intensity at the zenith appeared to correspond to 41° of the cyanometer. We know by Saussure's experiment, that this intensity increases with the rarity of the air, and that the same instrument indicated at the same period 20° at the priory of Chamouni, and 40° at the top of Mont-Blanc. This last mountain is 540 toises higher than the volcano of Teneriffe; and if, notwithstanding this difference, the sky is seen there of a less deep blue, we must attribute this phænomenon to the dryness of the African air, and the proximity of the torrid zone.

We collected air on the brink of the crater, which we meant to analyse on our voyage to America. The phial remained so well corked, that, on opening it ten days after, the water rushed in with impetuosity. Several experiments, made by means of nitrous gas in the narrow tube of Fontana's eudiometer, seemed to prove, that the air of the crater contained 0·09 less oxygen than the air of the sea; but I have little confidence in this result obtained by means which we now consider as very inexact. The crater of the Peak has so little depth, and the air is renewed with so much facility, it is scarcely probable, that the quantity of azot is greater there than on

the coasts. We knew also, from the experiments of Messrs. Gay-Lussac and Theodore de Saussure, that in the highest as well as in the lowest regions of the atmosphere, the air equally contains 0·21 of oxygen *.

We saw on the summit of the Peak no trace of psora, lecidea, or other cryptogamous plants; no insect fluttered in the air. We found however a few hymenopteras adhering to masses of sulphur moistened with sulphurous acid, and lining the mouths of the funnels. These are bees, which appear to have been attracted by the flowers of the spartium nubigenum, and which oblique currents of air had carried up to these high regions, like the butterflies found by M. Ramond at the top of Mont Perdu. The butterflies perished from cold, while the bees on the Peak were scorched on imprudently approaching the crevices where they came in search of warmth.

Notwithstanding the heat we felt in our feet on the edge of the crater, the cone of ashes remains covered with snow during several months

* During the stay Messrs. Gay-Lussac and myself made at the hospice of Mount Cenis, in March, 1805, we collected air in the midst of a strongly electrified cloud. This air, analysed in Volta's eudiometer, contained no hydrogen, and its purity did not differ 0·002 of oxygen from the air of Paris, which we had carried with us in phials hermetically sealed. On air collected at 3405 toises height, see *Annal. de Chimie*, t. 52, p. 92.

in the winter. It is probable, that under the cap of snow considerable hollows are found, like those we find under the glaciers of Switzerland, the temperature of which is constantly less elevated than that of the soil on which they repose*. The cold and violent wind, which blew from the time of sunrise, engaged us to seek shelter at the foot of the Piton. Our hands and faces were frozen, while our boots were burnt by the soil on which we walked. We descended in the space of a few minutes the Sugar Loaf which we had scaled with so much toil; and this rapidity was in part involuntary, for we often rolled down on the ashes. It was with regret that we quitted this solitary place, this domain where Nature towers in all her majesty; we soothed ourselves with the hope of once again visiting the Canary islands, but this, like many other plans which we then formed, has never been executed.

We traversed the Malpays but slowly; the foot finds no sure foundation on loose blocks of lava. Nearer the Station of the Rocks, the descent becomes extremely painful; the compact short-swarded turf is so slippery, that we were obliged to incline our bodies continually backward, in order to prevent our falling. In the sandy plain of Retama, the thermometer rose

* See the excellent work of Mr. Stapfer, Voy. Pittoresq. de l' Oberland, p. 61.

to 22·5°; and this heat seemed to us suffocating in comparison with the sensation of cold, which we had suffered from the air on the summit of the volcano. We were absolutely without water; our guides, not satisfied with drinking clandestinely the little provision of malmsey, for which we were indebted to Mr. Cologan's careful kindness, had broken our water vessels. Happily the bottle which contained the air of the crater escaped unhurt.

We at length enjoyed the refreshing breeze in the beautiful region of the arborescent erica and fern; we were enveloped in a thick bed of clouds stationary at six hundred toises above the plain. In crossing this, we remarked a phænomenon which was afterwards familiar to us on the declivities of the Cordilleras. Small currents of air chased trains of clouds with unequal velocity, and in opposite directions; and bore the appearance of streamlets of water in rapid motion and in all directions, amidst a great mass of stagnant waters. The causes of this partial motion of the clouds are probably very various; we may suppose it to arise from some impulsion at a great distance; from the slight inequalities of the soil, which reflects in a greater or less degree the radiant heat; from a difference of temperature kept up by some chemical action; or perhaps from a strong electric charge of the vesicular vapors.

As we approached the town of Orotava, we met great flocks of canaries*. These birds, well known in Europe, were in general uniformly green; some had a yellow tint on their backs; their note was the same as that of the tame canary. It is nevertheless remarked, that those which have been taken in the isle of the Great Canary, and in the islet of Monte Clara, near Lanzerota, have a stronger, and at the same time the most harmonious song. Under every zone, among birds of the same species, each flock has its peculiar note. The yellow canaries are a variety, which has taken birth in Europe; and those we saw in cages at Orotava and Santa Cruz had been bought at Cadiz, and in other ports of Spain. But of all the birds of the Canary islands, that which has the most heartsoothing song is unknown in Europe; this is the capirote, which no effort has been able to tame, so sacred to his soul is liberty. I have stood in admiration at his soft and melodious warbling, in a garden at Orotava; but I have never seen him sufficiently near, to know to what family he belongs. As to the parrots, which were supposed to have been seen at the period of Captain Cook's abode at Teneriffe, they never existed but in the narrative or

* Fringilla canaria. La Caille relates, in the narrative of his voyage to the Cape, that on Salvage island these canaries are so abundant, you cannot walk there in a certain season without breaking their eggs.

a few travellers, who have copied from each other. Neither parrots nor monkeys inhabit the islands of the Canaries; and though in the New Continent the former migrate as far as North Carolina, I doubt whether in the Old they have ever been met with beyond the 28th degree of north latitude.

Toward the close of day we reached the port of Orotava, where we heard the unexpected news, that the Pizarro would not set sail till the 24th or 25th. If we could have calculated on this delay, we should either have lengthened our stay* on the Peak, or made an excursion to the volcano of Chahorra. We passed the following day in visiting the environs of Orotava, and enjoying the agreeable company we found at Mr. Cologan's. We perceived, that the abode at Teneriffe was

* As a great number of travellers, who land at Santa Cruz, do not undertake the excursion to the Peak, because they are ignorant of the time which it takes, it may be useful to lay down the following data: In making use of mules as far as the Station of the English, it takes twenty-one hours from Orotava to arrive at the summit of the Peak, and return to the port; namely, from Orotava to the Pino del Dornajito three hours; from the Pino to the Station of the Rocks six hours; and from this station to the Caldera three hours and a half. I reckon nine hours for the descent. In this valuation I count only the time employed in walking, and no way that which is necessary to examine the productions of the Peak, or to take repose. Half a day is sufficient to go from Santa Cruz to Orotava.

interesting not only to those whose business is the study of nature; we found at Orotava several persons, who have a taste for literature and music, and who have transplanted into these distant climates the amenity of European society. In these respects, the Canary islands have no great resemblance to the other Spanish colonies, excepting the Havannah.

We were present, the eve of St. John, at a pastoral fête in the garden of Mr. Little. This gentleman, who had rendered great service to the Canarians during the last famine, has cultivated a hill covered with volcanic substances. He has formed in this delicious site an English garden, whence there is a magnificent view of the Peak, of the villages along the coast, and the isle of Palma, which limits the vast extent of the ocean. I cannot compare this prospect with any, except those of the bays of Genoa and Naples; but Orotava is greatly superior to both in the magnitude of the masses, and in the richness of vegetation. In the beginning of the evening, the slope of the volcano exhibited on a sudden a most extraordinary spectacle. The shepherds, in conformity to a custom, no doubt introduced by the Spaniards, though it dates from the highest antiquity, had lighted the fires of St. John. These scattered masses of fire, these columns of smoke driven by the wind, formed a fine contrast with the deep verdure of the forests, which covered the sides of

the Peak. Shouts of joy heard from afar were the only sounds, that broke the silence of nature in these solitary abodes.

Mr. Cologan's family has a country house nearer the coast than that I have just mentioned. The name given by the proprietor is appropriate to the sentiment, which this rural spot inspires. The house of *La Paz* was also connected with a circumstance that rendered it peculiarly interesting to us. M. de Borda, whose death we deplored, was its inmate during his last visit to the Canary islands. It was in a small neighbouring plain, that this gentleman measured the base, by which he determined the height of the Peak. In this geometrical operation, the great dracæna of Orotava served as a mark. If any well-informed traveller should some future day undertake a new measurement of the volcano with more exactness, and by means of astronomical repeating circles, he ought to measure the base, not near Orotava, but near *Silos*, at a place called *Bante*. According to M. Broussonet, there is no plain near the Peak of greater extent. In herbalizing near La Paz, we found a great quantity of lichen roccella on the basaltic rocks bathed by the waters of the sea. The archil of the Canaries is a very ancient branch of commerce; this lichen is however found in less abundance in the isle of Teneriffe, than in the desert islands of Salvage, La Graciosa, and L' Alegranza, or even in Canary and Hierro.

We left the port of Orotava on the 24th of June in the morning: we dined, as we passed through Laguna, with the French consul. He had the kindness to take charge of the geological collections* we had made, and which we destined for the king of Spain's cabinet of natural history. As we left the town, and turned our eyes toward the road of Santa Cruz, we were alarmed at seeing our vessel, the Pizarro, under way. On reaching the port, we learnt, that she was plying under an easy sail, to wait for us. The English vessels, that were stationed off the island of Teneriffe, had disappeared; and we had not a moment to lose to go on board. We embarked alone, for our fellow-travellers were Canarians, and at the end of their journey. We regretted in this number Don Francisco Salcedo, son of the late Spanish governor of Louisiana, whom we met with again at the isle of Cuba, on our return from the Orinoco.

Not to interrupt the narrative of the excursion to the top of the Peak, I have said nothing of the geological observations I made on the structure of this colossal mountain, and on the nature of the volcanic rocks of which it is composed. Before we quit the Archipelago of the Canaries, I shall delay a moment, and bring into one point of

* Mr. Hergen has described them in the *Annales de Ciencias naturales*, which he published jointly with Abbé Cavanilles.

view what relates to the physical picture of these countries.

The mineralogists who think, that the end of the geology of volcanoes is the classification of lavas, the examination of the crystals they contain, and their description according to their external characters, are generally very well satisfied, when they come back from the mouth of a burning volcano. They return loaded with numerous collections, which are the principal objects of their researches. This is not the feeling of those, who, without confounding descriptive mineralogy* with geognosy, endeavor to raise themselves to ideas generally interesting, and seek, in the study of nature, for answers to the following questions:

Is the conical mountain of a volcano entirely formed of liquified matter, heaped together by successive eruptions; or does it contain in its centre a nucleus of primitive rocks covered with lavas, which are these same rocks altered by fire? What are the affinities, which unite the productions of modern volcanoes with the basaltes, the phonolites, and those porphyries with basis of feldspar, which are without quartz, and which cover the Cordilleras of Peru and Mexico, as well as the small groups of the Monts d'Or, of Cantal, and of Mézen in France? Has the central nucleus of volcanoes been heated in its primitive position,

and raised up, in a softened state, by the force of the elastic vapours, before these fluids communicated, by means of a crater, with the external air? What is the substance, which, for thousands of years, keeps up this combustion, which is sometimes so slow, and at other times so active? Does this unknown cause act at an immense depth; or does this chemical action take place in secondary rocks lying on granite?

The farther we are from finding a solution of these problems in the numerous works hitherto published on Etna and Vesuvius, the greater is the desire of the traveller, to see with his own eyes. He hopes to be more fortunate than those who have preceded him; he wishes to form a precise idea of the geological relations, the volcano and the neighbouring mountains bear to each other: but, how often is he disappointed, when, on the limits of the primitive soil, enormous banks of tufa and puzzolana render every observation on the position and stratification impossible! We reach the inside of the crater with less difficulty than we at first expected, we examine the cone from its summit to its basis; we are struck with the difference in the produce of each eruption, and with the analogy which still exists between the lavas of the same volcano: but, notwithstanding the care with which we interrogate nature, and the number of partial observations which are presented at every step, we return from the summit of a burning

volcano less satisfied, than when we were preparing to go thither. It is after we have studied them on the spot, that the volcanic phenomena appear still more isolated, more variable, more obscure, than we figure them when consulting the narratives of travellers.

These reflections occurred to me on returning from the summit of the Peak of Teneriffe, the first unextinct volcano I had yet visited. They returned anew, whenever in South America, or in Mexico, I had occasion to examine volcanic mountains. If we reflect on the little progress, which the labours of mineralogists, and the discoveries in chemistry, have made toward the knowledge of the physical geology of mountains, we cannot help being affected with a painful sentiment; and this is felt still more strongly by those, who, questioning nature under different climates, are more occupied by the problems they have not been able to solve, than with the small number of results they have obtained.

The Peak of Ayadyrma, or of Echeyde*, is a conic and isolated mountain, placed in an islet of very small circumference. The learned, who do not take into consideration the whole surface of the Globe, believe, that these three circumstances are common to the greater part of volcanoes. They

* The word *Echeydé*, which signifies *Hell* in the language of the Guanches, has been corrupted by the Europeans into Teyde.

cite, in support of their opinion, Etna, the Peak of the Azores, the Solfatara of Guadaloupe, the Trois-Salazes of the Isle of Bourbon, and that archipelago of volcanoes contained in the Indian Sea and the Great Ocean. In Europe and in Asia, as far as the interior of the latter continent is known, no burning volcano is situate in a chain of mountains; all being at a greater or less distance from these chains. In the New World, on the contrary, and this fact deserves the greatest attention, the volcanoes the most stupendous for their masses form a part of the Cordilleras themselves. The mountains of mica-slate and gneiss in Peru and New Grenada immediately touch the volcanic porphyries of the provinces of Quito and Pasto. To the south and north of these countries, in Chili and in the kingdom of Guatimala, the active volcanoes are grouped in rows. They are the continuation, as we may say, of the chains of primitive rocks; and if the volcanic fire has broken forth in some plain far from the Cordilleras, as in mount Sangay and Jorullo *, we must consider this phænoménon as an exception to the law, which nature seems to have imposed on these regions. I here ought to state again these geological facts, because this pretended isolated situation of every

* Two volcanoes of the provinces of Quixos and Mechoacan, one in the southern, and the other in the northern hemisphere.

volcano has been opposed to the idea, that the Peak of Teneriffe, and the other volcanic summits of the Canary Islands, are the remains of a submerged chain of mountains. The observations, which have been made on the grouping of the volcanoes in America, prove, that the ancient state of things represented in the *conjectural map of the Atlantic* by M. Bory de St. Vincent* is no way in contradiction to the acknowledged laws of nature; and that nothing opposes our admitting, that the summits of Porto Santo, Madeira, and the Fortunate Islands, may heretofore have formed, either a distinct range of primitive mountains, or the western extremity of the chain of Atlas.

The Peak of Teyde forms a pyramidal mass like Etna, Tungurahua, and Popocatepetl. This physiognomic character is very far from being common to all volcanoes. We have seen some in the southern hemisphere, which, instead of having the form of a cone or a bell, are lengthened in one direction, having the ridge sometimes smooth, and

* The question, whether the traditions of the ancients respecting the Atlantis are founded on historical facts, is entirely different from this, whether the Archipelago of the Canaries and the adjacent islands are the wrecks of a chain of mountains, rent and sunk in the sea in one of the great convulsions of our Globe. I do not pretend to form any opinion in favour of the existence of the Atlantis; but I endeavour to prove, that the Canaries have no more been created by volcanoes, than the whole body of the smaller Antilles has been formed by madrepores.

at others rough with small pointed rocks. This structure is peculiar to Antisana and Pichincha, two burning mountains of the province of Quito; and the absence of the conic form ought never to be considered as a reason excluding a volcanic origin. I shall develope in the progress of this work some of the analogies, which I think I have perceived between the physiognomy of volcanoes and the antiquity of their rocks. It is here sufficient to observe in general, that the summits, which are still subject to eruptions of the greatest violence, and at the nearest periods to each other, are *slender peaks* of a conic form; that the mountains with *lengthened summits*, and rugged with small stony masses, are very old volcanoes, and near being extinguished; and that rounded tops in the form of *domes*, or bells, indicate those problematic porphyries, which are supposed to have been heated in their primitive place, penetrated by vapours, and forced up in a softened state, without having ever flowed as real lithoidal lavas. To the first * of these distinctions belong Cotopaxi, the Peak of Teneriffe, and that of Orizava in Mexico. The second † is common to Cargueirazo and Pichincha, in the province of Quito; to the volcano of Puracey, near Popayan; and perhaps also to Hecla, in Iceland. The third‡ and last is found

* Picturesque Atlas, folio, Pl. 10.

† Ibid. Pl. 61.

‡ Ibid, Pl. 16.

in the majestic figure of Chimborazo, and, if it be permitted to place by the side of this colossus a hill of Europe, in the Great Sarcouy in Auvergne.

In order to form a more exact idea of the external structure of volcanoes, it is important to compare their perpendicular height with their circumference. This however cannot be done with any exactness, unless the mountains are isolated, and placed on a plain which is nearly on a level with the sea. In calculating the circumference of the Peak of Teneriffe in a curve passing through the port of Orotava, Garachico, Adexe, and Guimar, and setting aside the prolongations of its basis towards the forest of Laguna, and the north-east cape of the island, we find that this extent is more than 54000 toises. The height of the Peak is consequently one twenty-eighth of the circumference of its basis. Mr. Von Buch found a thirty-third for Vesuvius; and, which perhaps is less certain, a thirty-fourth for Etna *. If the slope of

* Gilbert, Annalen der Physik, B. 5, p. 455. Vesuvius is 133,000 palmas, or eighteen nautical miles in circumference. The horizontal distance from Resina to the crater is 3700 toises. Italian mineralogists have estimated the circumference of Etna at 840,000 palmas, or 119 miles. With these data, the ratio of the height to the circumference would be only a seventy-second; but I find on tracing a curve through Catania, Palermo, Bronte, and Piemonte, only 62 miles in circumference according to the best maps. This increases the ratio to a fifty-fourth. Does the basis fall on the outside of the curve that I assume?

these three volcanoes were uniform from the summit to its basis, the Peak of Teyde would have an inclination of 12° 29′, Vesuvius 12° 41′, and Etna 10° 15′; a result which must astonish those, who do not reflect on what constitutes an average slope. In a very long ascent, slopes of three or four degrees alternate with others which are inclined from 25 to 30 degrees; and the latter only strike our imagination, because we think all the slopes of mountains more steep than they really are. I may cite in support of this consideration the example of the ascent from the port of Vera Cruz to the elevated plain of Mexico. It is on the eastern slope of the Cordilleras that a road has been traced, which for ages has not been frequented except on foot, or on the back of mules. From Encero to the small Indian village of Las Vigas, there are 7500 toises of horizontal distance; and Encero being, according to my barometric measurement, 746 toises lower than Las Vigas, the result, for the mean slope, is only an angle of 5° 40′.

I have drawn on the same plate, the profiles of the Peak of Teneriffe, Cotopaxi, and Vesuvius. I could have wished to have substituted Etna for this last mountain, because its form is more analogous to that of the two volcanoes of America and Africa; but I chose to trace only the outlines of mountains that I had visited and measured myself; and with respect to Etna I should have wanted data

for the intermediary heights. I ought also to observe, that, in the three profiles, the scales of distances and of heights have the same proportions. The distances have been determined after the charts of Zanoni, Borda, and La Condamine. The reader versed in the practice of levelling will not be astonished at the very gentle slope, which these profiles seem to indicate. In nature, an inclined plane of an angle of 35° appears to be 50°: we scarcely dare go down a hill of 22° slope in a carriage; and the parts of the volcanic cones, that are inclined 40° or 42_0, are almost inaccessible, though the foot may form steps by plunging it in the ashes. I have recorded in a note * the

* In places where there were at the same time slopes covered with tufted grass and loose sands I took the following measures:

5°, slope already of a very marked inclination. In France the high roads must not exceed 4° 46′ by law;

15°, slope extremely steep, and which we cannot descend in a carriage;

37°, slope almost inaccessible on foot, if the bottom be a naked rock, or a turf too thick to form steps. The body falls backwards when the tibia makes a smaller angle than 53°, with the sole of the foot;

42°, the steepest slope that can be climbed on foot in a ground that is sandy, or covered with volcanic ashes.

When the slope is 44°, it is almost impossible to scale it, though the ground permits the forming of steps by thrusting in the foot. The cones of volcanoes have a medium slope from

experiments I made on the difficulties arising from the declivities in mountainous countries.

Isolated volcanoes, in the most distant regions, are very analogous in their structure. At great elevations all have considerable plains, in the middle of which arises a cone perfectly circular. Thus at Cotopaxi the plains of Suniguaicu extend beyond the farm of Pansache. The stony summit of Antisana, covered with eternal snow, forms an islet in the midst of an immense plain, the surface of which is twelve leagues square, while its height exceeds that of the Peak of Teneriffe two hundred toises. At Vesuvius, at three hundred and seventy toises high, the cone detaches itself from the plain of Atrio del Cavallo. The Peak of Teneriffe presents two of these elevated plains, the uppermost of which, at the foot of the Piton, is as high as Etna, and of very little extent; while the lowermost, covered with tufts of retama (spartium nubigenum), reaches as far as the Estancia de los Ingleses. This rises above the level of the sea almost as high as the city of Quito, and the summit of Mount Lebanon.

The greater the quantity of matter that has issued from the crater of a mountain, the more

33° to 40°. The steepest parts of these cones, either of Vesuvius, the Peak of Teneriffe, the volcano of Pichincha, or Jorullo, are from 40° to 42°. A slope of 55° is quite inaccessible. If seen from above it would be estimated at 75°.

elevated is its cone of ashes in proportion to the perpendicular height of the volcano itself. Nothing is more striking under this point of view, than the difference of structure between Vesuvius, the Peak of Teneriffe, and Pichincha. I have chosen this last volcano in preference, because its summit* enters scarcely within the limit of the perpetual snows. The cone of Cotopaxi, the form of which is the most elegant and most regular hitherto known, is 540 toises in height; but it is impossible to decide, whether the whole of this mass is covered with ashes.

Names of the volcanoes.	Total height in toises.	Height of the cone covered with ashes.	Proportion of the cone to the total height.
Vesuvius	606	200	$\frac{1}{3}$
Peak of Teneriffe	1904	84	$\frac{1}{22}$
Pichincha	2190	240	$\frac{1}{10}$

This table seems to indicate, what we shall have an opportunity of proving more amply hereafter, that the Peak of Teneriffe belongs to that

* I have measured the summit of Pichincha, that is the small mountain covered with ashes above the Llano del Vulcan, to the north of Alto de Chuquira. This mount has not however the regular form of a cone. As to Vesuvius, I have indicated the mean height of the Sugar-Loaf, on account of the great difference between the two edges of the crater.

group of great volcanoes, which, like Etna and Antisana, have had more copious eruptions from their sides than from the summit. Thus the crater at the extremity of the Piton, which is called the Caldera, is extremely small; and this diminutiveness had already struck M. de Borda, and other travellers, who took little interest in geological investigations.

As to the nature of the rocks which compose the soil of Teneriffe, we must first distinguish between productions of the present volcano, and the range of basaltic mountains, which surround the Peak, and which do not rise more than five or six hundred toises above the level of the Ocean. Here, as well as in Italy, Mexico, and the Cordilleras of Quito, the rocks of trapp-formation * are at a distance from the currents of recent lavas; every thing shows, that these two classes of substances, though they owe their origin to similar phænomena, date from very different periods. It is important to geology, not to confound the currents of modern lavas, the heaps of basalt, greenstone, and phonolite, which are dispersed over the primitive and secondary formations, with those porphyroid masses with basis of compact feldspar †, which perhaps have never been per-

* The *trapp-formation* includes the basaltes, greenstone *(grunstein)*, the trappean porphyries, the phonolites or *porphyrschiefer*, &c.

† These petrosiliceous masses contain vitreous and often

fectly liquified, but which do not less belong to the domain of volcanoes.

In the isle of Teneriffe strata of tufa, puzzolana, and clay, separate the range of basaltic hills from the currents of recent lithoid lavas, and from the eruptions of the present volcano. In the same manner as the eruptions of Epomeo in the isle of Ischia, and those of Jorullo in Mexico, have taken place in countries covered with trappean porphyry, ancient basalt, and volcanic ashes, so the Peak of Teyde has raised itself amidst the wrecks of submarine volcanoes. Notwithstanding the difference of composition in the recent lavas of the Peak, there is a certain regularity of position, which must strike the naturalist the least skilled in geognosy. The great elevated plain of Retama separates the black, basaltic, and earthlike lava, from the vitreous and feldsparry lava, the basis of which is obsidian, pitchstone, and phonolite. This phænomenon is so much the more remarkable, as in Bohemia and other parts of Europe, the *porphyrschiefer* with

calcined crystals of feldspar, of hornblende, of pyroxene, a little of olivine, but scarcely any quartz. To this very ambiguous formation belong the trappean porphyries of Chimborazo and of Riobamba in America, of the Euganean mountains in Italy, and of the Siebengebirge in Germany; as well as the *domites* of the Great-Sarcuy, of Puy-de-Dome, of the Little-Cleirsou, and of one part of the Puy Chopine in Auvergne.

base of phonolite * covers also the convex summits of the basaltic mountains.

We have already observed, that from the level of the sea to Portillo, and as far as the entrance on the elevated plain of the Retama, that is two thirds of the total height of the volcano, the ground is so covered with plants, that it is difficult to make geological observations. The currents of lava, which we discover on the slope of Monte Verde, between the beautiful spring of Dornajito and Caravela, are black masses, altered by decomposition, sometimes porous, and with very oblong pores. The basis of these lower lavas is rather wacke than basalt; when it is spongy, it resembles the amygdaloids † of Frankfort on the Main. Its fracture is generally irregular; wherever it is conchoidal, we may presume, that the cooling was more rapid, and the mass was exposed to a less powerful pressure. These currents of lava are not divided into regular prisms, but into very thin layers, not very regular in their inclination; they contain much olivine, small grains of magnetic iron, and augits, the colour of which often varies from a deep leek green to an olive green, and which might be mistaken for crystallized olivine, though no transition from one to the other of these sub-

* *Klingstein.* Werner.

† *Wakkenartiger mandelstein* of Steinkaute.

stances exists *. Hornblende, or amphibole, is in general very rare at Teneriffe, not only in the modern lithoid lavas, but also in the ancient basalts, as has been observed by M. Cordier, who resided longer at the Canaries than any other mineralogist. Nepheline, leucite, idocrase, and mejonite have not yet been seen at the Peak of Teneriffe; for a reddish gray lava, which we found on the slope of Monte Verde, and which contains small microscopic crystals, appears to me to be an intimate mixture of basalt and analcime †. In the same manner the lava of La Scala, with which the city of Naples is paved, offers an intimate mixture of basalt, nepheline, and leucite. With respect to this last substance, which has hitherto been observed only at Vesuvius, and in the environs of Rome, it exists perhaps at the Peak of Teneriffe, in the old currents of lava that are covered by more recent ejections.

* *Steffens, Handbuch der Oryktognosie*, T. i, s. 364. The crystals which Mr. Friesleben and myself have made known under the denomination of foliated olivine *(blættriger olivin)* belong, according to Mr. Karsten, to the pyroxene, augit. Journal des Mines de Frieberg, 1791, p. 215.

† This substance, which M. Dolomieu discovered in the amygdaloids of Catania in Sicily, and which accompanies the stilbites of Fassa in Tyrol, forms, with the chabasie of Haüy, the genus cubicit of Werner. M. Cordier found at Teneriffe zeolite in an amygdaloid which covers the basaltes of La Punta di Naga.

Vesuvius during a long series of years* has also thrown out lavas without leucites: and if it be true, as Mr. Von Buch has rendered very probable†, that these crystals are formed only in the currents, which flow either from the crater itself, or very near its brink, we must not be surprised, if we do not find them in the lavas of the Peak, which are almost all owing to lateral eruptions, and which consequently have been exposed to an enormous pressure in the interior of the volcano.

In the plain of Retama, the basaltic lavas disappear under heaps of ashes, and pumice stone reduced to powder. Thence to the summit, from 1500 to 1900 toises in height, the volcano exhibits only vitreous lava with basis of pitchstone‡ and obsidian. These lavas, destitute of hornblende and mica, are of a blackish brown, often varying to the deepest olive green. They contain large crystals of feldspar, which are not fissured, and seldom vitreous. The analogy of those decidedly volcanic masses with the resinit porphyries§ of the valley of Tribisch in Saxony is very remarkable; but the latter, which belong to a very ex-

* For instance in 1760, 1794, and 1805.

† *Leopold von Buch, Geognostische Beob.* t. 2, s. 221. *Gilberts Ann.* t. 6, s. 53. The existence of leucites (amphigènes) at Arendahl in Norway, in Scotland, in the Pyrenees, in Transylvania, in Mexico, does not rest on any very accurate observations.

‡ Petrosilex résinite. Haüy.

§ Pechstein-porphyr. Werner.

tended and metalliferous formation of porphyry *, often contain quartz, which is wanting in the mo-

* We can now distinguish four formations *(hauptniederlagen)* of porphyry. The *first* is primitive, and found in subordinate strata in the gneiss, and the mica-slate (Isaac at Freyberg). The *second* alternates with syenit: it is older than grauwakke, and belongs most probably already to the transition mountains *(uebergangs gebirge)*. It contains beds of pitchstone and obsidian, and even granular limestone, of which we see instances near Meissen in Saxony: it is extremely rich in metals, and is found in Mexico (at Guanaxuato, Regla, &c.), in Norway, in Sweden, and at Schemnitz in Hungary. The porphyry of Norway covers, near Skeen, grauwakke and mandelstein; it encloses crystals of quartz. Near Holmestrandt, a bed of basalt, which abounds in augit, is interposed among the transition porphyry. The rock of Schemnitz (the *saxum metalliferum* of Ferber and Born), which lies on the thonschiefer, is destitute of quartz, and contains hornblende and common feldspar. It is this second formation of porphyry, which appears to have been the centre of the oldest volcanic revolutions. The *third* formation belongs to the ancient sandstone *(todtesliegende)*, which seems as a basis to the alpine limestone (alpen-kalkstein or zechstein): it contains mandelstein (amygdaloides) mixed with agate (at Oberstein, in the Palatinate), and sometimes covers (in Thuringia) strata of coal. The *fourth* formation of porphyries is trappean, destitute of quartz, and, especially in America, often mixed with olivin and augit; it accompanies basalts, greenstone, and phonolites (Chimborazo, the province de los Pastos, Drachenfels near Bonn, Puy-de-Dôme). The classification of the porphyries is accompanied with great difficulties. Granite, gneiss, mica-slate or micaceous schist, thonschiefer, and chloritschiefer, form a series, in which each rock is connected with that which precedes it. The porphyries, on

dern lavas. When the basis of the lavas of the Malpays changes from pitchstone to obsidian, the color is paler, and mixed with gray; in this case, the feldspar passes by imperceptible gradations from the common to the vitreous. Sometimes both varieties meet in the same fragment, as we observed also in the trappean porphyries of the valley of Mexico. The feldsparry lavas of the Peak, of a much less black color than those of Arso, in the isle of Ischia, whiten at the edge of the crater from the effect of the acid vapors; but their inside

the contrary, are found, as it were, isolated in the geognostical system; they offer transitions into each other, but not into the substances on which they repose. (*Buch. Geognost. Beob.* t. 1, s. 56). As in the course of this work volcanic and nonvolcanic porphyries may often occur, it appears to me indispensible, to exhibit the general table of the formation traced by the illustrious chief of the Freyberg school, from his own observation, those of Von Buch, Esmark, and Friesleben, and mine. The great divisions, which are susceptible of much improvement, are independent of any hypothesis on the origin of porphyries, as they relate only to position, superposition, and relative age. The four formations just described, may be distinguished by the names of primitive porphyries *(urporphyre)*, of transition porphyries *(uebergangsporphyre)*, secondary porphyries *(flœzporphyre)*, and trappean porphyries *(trapporphyre)*. If we confound the second and fourth of these formations under the common name of porphyry-lavas, we throw geognosy back into the obscurity from which it is scarce freed: we might as well class gneiss, mica-slate, and thonschiefer, under the general name of laminar and schistose rocks.

is no way deprived of color like that of the feldsparry lavas of the solfaterra at Naples, which perfectly resemble the trappean porphyries at the foot of Chimborazo. In the middle of the Malpays, at the height of the cavern of ice, we found among the vitreous lavas with the pitchstone and obsidian basis, blocks of real greenish-gray, or mountain green phonolite, with a smooth fracture, and divided into thin laminæ, sonorous and keen edged. These masses were the same as the porphyrschiefer of the mountain of Bilin in Bohemia; we recognised in them small long crystals of vitreous feldspar.

This regular disposition of lithoid basaltic lava and feldsparry vitreous lava is analogous to the phænomena of all trappean mountains; it reminds us of those phonolites lying in very ancient basalts, those intimate mixtures of augit and feldspar which cover the hills of wakke or porous amygdaloids: but why are the porphyritic or feldsparry lavas of the Peak found only on the summit of the mountain? Should we conclude from this position, that they are of a more recent formation than the lithoid basaltic lava, which contains olivine and augit? I cannot admit this last hypothesis; for lateral eruptions may have covered the feldsparry nucleus, at a period when the crater had ceased its activity. At Vesuvius also, we perceive small crystals of vitreous feldspar only in the very ancient lavas of the Somma. These lavas, setting

aside the leucite, very nearly resemble the phonolitic productions of the Peak of Teneriffe. In general the farther we go back from the period of modern eruptions, the more appearance the currents, increasing both in size and extent, acquire of real rocks, in the regularity of their position, in their division into parallel strata, or in their independance of the present form of the ground.

The Peak of Teneriffe is, next to Lipari, the volcano that has produced most obsidian. This abundance is so much the more striking, as in other regions of the Earth, in Iceland, in Hungary, in Mexico, and in the kingdom of Quito, we meet with obsidian only at great distances from burning volcanoes. Sometimes they are scattered over the fields in angular pieces, for instance, near Popayan, in South America; at other times they form isolated rocks, as at Quinche, near Quito; in other places, and this position is very remarkable, they are disseminated in perlstein, as at Cinapecuaro, in the province of Méchoacan*, and at Cabo de Gates, in Spain. At the Peak of Teneriffe, the obsidian is not found toward the basis of the volcano, which is covered with modern lava: it is frequent only towards the summit, especially from the plain of Retama, where very fine specimens may be collected. This peculiar position, and the circumstance that the

* To the west of the city of Mexico.

obsidian of the Peak has been ejected by a crater, which for ages past has thrown out no flames, are favourable to the opinion; that volcanic vitrifications, wherever they are found, are to be considered as of very ancient formation.

Obsidian, jade, and touchstone*, are three minerals, which nations ignorant of the use of brass or iron, in all ages, employed to make keen-edged weapons. In the most distant parts of the Globe, necessity fixed their choice on the same substance. We see wandering hordes have dragged with them, in their distant excursions, stones, the natural position of which the mineralogist has not yet been able to discover. Hatchets of jade, covered with Azteck hieroglyphics, which I brought from Mexico, resemble both in their form and nature those made use of by the Gauls, and those we find among the islanders of the Pacific Ocean. The Mexicans dug obsidian in mines, which took up a vast extent of ground; and of it made knives, sword-blades, and razors. In like manner the Guanches, who called obsidian by the name of *tabona*, fixed splinters of this mineral to the ends of their lances. They carried on a considerable trade in it with the neighbouring islands; and from the consumption thus occasioned, and the quantity of obsidian which must have been broken in the fabrication, we may presume, that this mi-

* Lydischerstein.

neral is become scarce from the lapse of ages. We are surprised to see an Atlantic nation substituting, like the Americans, vitrified lava for iron. In both countries, this variety of lava was employed as an object of ornament: the inhabitants of Quito made beautiful looking glasses with an obsidian divided into parallel laminæ.

There are three varieties of obsidian at the Peak. Some form enormous blocks, several toises long, and often of a spheroidal figure. We might suppose, that they had been thrown out in a softened state, and had undergone a rotary motion. They contain a quantity of vitreous feldspar, of a snow white color, and the most brilliant pearly lustre. These obsidians are nevertheless but little transparent on the edges, almost opake, of a brownish black, and of an imperfect conchoidal fracture. They pass into pitchstone; and we may consider them as porphyries with a basis of obsidian. The second variety is found in fragments much less considerable. It is in general of a greenish black, sometimes of murky gray, very seldom of a perfect black, like the obsidian of Hecla and Mexico. Its fracture is perfectly conchoidal, and it is extremely transparent on the edges. I have found in it neither hornblende nor pyroxene, but some small white points, which seem to be feldspar. All the obsidians of the Peak are free from those gray masses of pearl or lavender blue, striped, and in separate pieces of the form of wedges, contain-

ed in the obsidian of Quito, Mexico, and Lipari, and which resemble the fibrous plates of the *crystallites* of our glass houses, on which Sir James Hall, Dr. Thomson, and M. Fleuriau de Bellevue, have published some very curious observations *.

The third variety of obsidian of the Peak is the most remarkable of the whole, from its connection with pumice stones. It is, like the former, of a greenish black, sometimes of a murky gray, but its very thin plates alternate with layers of pumice stone. Dr. Thomson's fine collection at Naples contained similar examples of lithoid lava of Vesuvius, divided into very distinct plates, only a line thick. The fibres of the pumice stone of the Peak are very seldom parallel to each other, and perpendicular to the strata of obsidian; they are most commonly irregular, asbestoidal, like fibrous glass-gall; and instead of being disseminated in the obsidian, like crystallites, they are found simply adhering to one of the external surfaces of this substance. During my stay at Madrid, Mr. Hergen showed me several specimens

* *Bibl. Britann.* t. 15, p. 340; t. 27, p. 147. *Edin. Trans.*, vol. 5, Pl. 1, No. 3. *Journ. de Phys. an* 12, *floréal, et an* 13 *prairial.* The name of crystallites has been given to the crystallized thin plates included in glass cooling slowly. Dr. Thompson and others indicate by the word *verre glastenisé*, glass which by slow cooling is wholly *unvitrified*, and has assumed the appearance of a fossile substance, or real *glass stone.*

in the mineralogical collection of Don Jose Clavijo; and for a long time the Spanish mineralogists considered them as undoubted proofs, that pumice stone owes its origin to obsidian, in some degree deprived of color, and swelled by volcanic fire. I was formerly of this opinion, which must be confined to one variety only of pumice. I even thought, with many other geologists, that obsidian, so far from being vitrified lava, belonged to rocks that were not volcanic; and that the fire, forcing its way through the basalts, the green stone rocks, the phonolites, and the porphyries with basis of pitchstone and obsidian, the lavas and pumice stone, were no other than these same rocks altered by the action of the volcanoes. The deprivation of color and extraordinary swelling, which the greater part of the obsidians undergo in a forge fire, their transition into pechstein, and their position in regions very distant from burning volcanoes, appear* to be phænomena very difficult to reconcile, when we consider the obsidians as volcanic glass. A more profound study of nature, new journeys, and observations made on the productions of burning volcanoes, have led me to renounce those ideas.

It appears to me at present extremely probable, that obsidians, and porphyries with basis of obsidian, are vitrified masses, the cooling of which has

* Ann. du Mus. d'Hist. nat. t. 3, p. 398.

been too rapid to change them into lithoid lava. I consider even the perlstein of Mr. Esmarck as an unvitrified obsidian: for among the minerals in the king's cabinet at Berlin there are volcanic glasses from Lipari, in which we see striated crystallites, of a pearl gray color, and of an earthy appearance, form gradual approches to a granular lithoid lava, like the perlstein of Cinapecuaro, in Mexico. The oblong bubbles observed in the obsidians of each of the continents are incontestible proofs of their ancient state of igneous fluidity; and Dr. Thomson possesses specimens from Lipari, which are very instructive in this point of view, because fragments of red porphyry, or porphyry lavas, which do not entirely fill up the cavities of the obsidian, are found enveloped in them. We might say, that these fragments had not time to enter into complete solution in the liquified mass; they contain vitreous feldspar, and augit, and are the same as the celebrated columnar porphyries of the island of Panaria, which, without having made part of a current of lavas, seem raised up in the form of hillocks, like so many porphyries in Auvergne, in the Euganean mountains, and in the Cordilleras of the Andes.

The objections against the volcanic origin of obsidians, drawn from their speedy loss of color, and their swelling by a slow fire, are deprived of their force by the ingenious experiments of Sir James Hall. These experiments prove, that a stone,

which is fusible only at thirty eight degrees of Wedgwood's pyrometer, yields a glass, that softens at fourteen degrees; and that this glass, melted again and unvitrified *(glasténisé)*, is fusible again only at thirty five degrees of the same pyrometer. I applied the blowpipe to some black pumice stones from the volcano of the Isle of Bourbon, which, on the slightest contact of the flame, whitened and melted into an enamel.

But whether obsidians be primitive rocks, which have undergone the action of volcanic fire, or lavas repeatedly melted within the crater, the origin of the pumice stones which they envelope at the Peak of Teneriffe is not less problematic. This subject is the more worthy of being investigated, since it is generally interesting to the geology of volcanoes; and since an excellent mineralogist*, after having visited Italy and the adjacent islands with great attention, affirms, that it is highly improbable, that pumice stone owes its origin to the swelling of obsidian.

On recurring to the observations, which I have had the means of making in Europe, in the Canary islands, and in America, I conclude, that the term *pumice stone* does not denote a simple fossil, like the word calcedony, opal, or pyroxene, but that it indicates only a certain state, a capillary or

* M. Fleuriau de Bellevue, Journ. de Phy. t. 60, p. 451 et 461.

fibrous form, under which several substances thrown out by volcanoes are seen. The nature of these substances is as different as the thickness, the tenacity, the flexibility, the parallelism, or the direction of their fibres. We may consequently doubt, whether pumice ought to hold any place in a system of oryctognosy; or whether, like compound rocks, they do not rather belong to the domain of geognosy. I have seen black pumice stones, in which augit and hornblende are easily recognised; they are less light, of a spongy texture, and rather cellular than fibrous. We might be tempted to think, that these substances owe their origin to basaltic lavas. I have observed them in the volcano of Pichincha, as well as in the tufa of Pausilippo, near Naples. Other pumice stones, and these the most common, are of a grayish white, or of a blueish gray, with numerous parallel fibres, and containing vitreous feldspar and mica. The greater part of the pumice stones of the Æolian islands, and those I collected at the foot of the volcano of Sotara, near Popayan, belong to this class. They seem to have been originally granitic rocks, as Dolomieu first recognised in his voyage to the islands of Lipari*. Assembled in enormous blocks, they sometimes form whole mountains far from any active volca-

* *Dolomieu, Voy. aux Iles de Lipari*, p. 67, *Id. Mém. sur les Iles Ponces*, p. 89.

no. It is thus that we find obsidians between Llactacunga and Hambato, in the kingdom of Quito, covering the space of a league square; and in Hungary, where they were accurately examined by Mr. Esmarck. This singular position made the Danish mineralogist think, that they belonged to the secondary or floetz formation; and that the volcanic fire had traversed the strata of pumice, as well as the obsidians and the basalts, which he equally considers as not of volcanic origin. A third variety of pumice is that with fragile fibres, somewhat thick, transparent on the edges, and of an almost vitreous lustre, which exhibits the transition from the granitic pumice stone to the capillary glass. This variety, which is adherent to the green and grayish obsidian of the Peak of Teneriffe, seems to have been produced by the action of the fire on matters already vitrified.

From the whole of these considerations it results, that it is as erroneous to consider the whole of the pumice stones as tumefied obsidians, as to look for their origin exclusively in granites rendered fusile and fibrous by the action of fire, or of acid vapors. It is possible, that the obsidians themselves were only liquified granites*; but we

*We meet sometimes, though very rarely, with mica in the obsidians: and Dolomieu thinks he has found not only feldspar and mica, but also quartz, in the granitic pumice. Voy. aux Iles Ponces, p. 122; Voy. aux Iles de Lipari, p. 83.

must distinguish, with Spallanzani, between the pumices which draw their origin directly from primitive rocks, and those which, being only altered volcanic productions, vary like them in their composition*. A certain state, into which several heterogeneous substances pass, or the result of a particular mode of action, are insufficient to establish a *species* in the classification of simple minerals.

The experiments of Mr. Da Camara, and those I made in 1802, come in support of the opinion, that the pumice stones adherent to the obsidians of the Peak of Teneriffe do not unite to them accidentally, but are produced by the expansion of an elastic fluid, which is disengaged from the compact vitreous matter. This idea had for a long time occupied the mind of a person highly distinguished for his talents and reputation at Quito, who, unacquainted with the labors of the mineralogists of Europe, had devoted himself to researches on the volcanoes of his country. Don Juan de Larea, one of those lately sacrificed to the fury of faction, had been struck with the phænomena exhibited by obsidians exposed to a white

* The word *lava* is still more vague than that of pumice stone. "It is as little philosophical to require an exterior description of lava, as a mineral species, as it is to ask the general characters of the mass, that fills the veins of ore." Leop. Von Buch, *Geognost. Beob.* vol. 2, p. 173.

heat. He had thought, that, wherever volcanoes act in the centre of a country covered with porphyry with base of obsidian, the elastic fluids must cause a swelling of the liquified mass, and act an important part in the earthquakes preceding eruptions. Without adopting an opinion, which seems somewhat bold, I made, in concert with Mr. Larea, a series of experiments on the tumefaction of the volcanic vitreous substances at Teneriffe, and on those which are found at Quinché, in the kingdom of Quito. To judge of the augmentation of their bulk, we measured pieces exposed to a forge fire of moderate heat by the water they displaced from a cylindric glass, enveloping the spongy mass with a thin coating of wax. According to our experiments, the obsidians swelled very unequally: those of the Peak and the black varieties of Cotopaxi and of Quinché increased near five times their bulk. The swelling on the contrary was very little perceptible in the obsidians of the Andes, the color of which is a brown approaching to red. When the reddish variety is mingled, in thin plates, with the black and blackish gray obsidians, the striated mass resembles porcelain jasper*; and the opake parts resist the action of the fire for a length of time, while those which are less rich in oxid of iron, lose their color and tu-

* Porzellan-jaspis of Werner: thermantide porcellanite of Haüy.

mefy. What is this substance, the disengaging of which reduces the obsidian to the state of white pumice, sometimes fibrous, and at other times spongy, with oblong cells? It is easy to perceive, that it really loses a coloring principle; and that the deprivation of color is not merely apparent, that is to say, it is not owing to the extreme tenuity to which the laminæ and fibres of the volcanic glass are reduced. Can we admit, that this coloring principle* is a hydruret of carbon, analogous to that which perhaps exists in the flint so easy to whiten by fire? Some experiments, which I made at Berlin in 1806 jointly with Messrs. Rose and Karsten, on the obsidians of Teneriffe, Quito, Mexico, and Hungary, in porcelain *retorts*, did not yield any results that were satisfactory.

Nature probably employs very different means to produce the spongy and vitreous pumices of Teneriffe, the pumices with parallel fibres of the Æolian islands and of Llactacunga†, and the capillary vitrifications of the Isles of Bourbon, which sometimes resemble a spider's web‡. We may

* It is remarkable, that this principle is not always equally volatile. M. Gay-Lussac saw lately obsidians of Faroë not whiten at a degree of heat, which totally deprived of color obsidians of Mexico, though from exterior appearance it would have been difficult to distinguish these substances from one another.

† Between Quito and Riobamba.

‡ Bory de St. Vincent, Voy. aux Iles d'Afrique, t. 3, p. 50.

admit, that these differences consist principally in the degree of heat of the volcanic fire, in the pressure under which this fire acts, and in the nature of the rocks altered by it. Above all, the pressure, which the obsidians undergo in their fusion, explains why these substances, except some varieties which I collected near Popayan, are never found whitened. Those of the pumice stones that have the appearance of being formed at great depths, are fibrous, of silky lustre, which abound more in mica than in feldspar, and in which, on the Andes, blocks of eight or ten toises in length have the fibres exactly parallel with each other, and perpendicular to the direction of the strata. Several volcanoes too do not throw out any pumice stone; and those that do, eject them only by their crater, after the flowing of the lavas. Several mineralogists think, that primitive granular rocks may be changed progressively, and in their place, either by the fire, or by a penetration of hot and acid vapors, into porphyroidal masses, of a foliated or fibrous texture. This opinion seems supported by the existence of the fissured and fibrous feldspars, which we found in the trappean porphyries of Quito. These crystals resemble rhomboidal fragments of pumice stone, disseminated in a *domite* deprived of color.

The color of the pumice stones of the Peak leads to another important observation. The sea of white ashes, which encircles the Piton, and co-

vers the vast plain of Retama, is a certain proof of the ancient activity of the crater: for in all volcanoes, even when there are lateral eruptions, the ashes and the *rapilli* issue jointly with the vapors only from the opening at the summit of the mountain. Now, at Teneriffe, the black *rapilli* extend from the foot of the Peak to the seashore; while the white ashes, which are only pumice ground to powder, and among which I have discovered, with a lens, fragments of vitreous feldspar and pyroxene, exclusively occupy the region next to the Peak. This particular distribution seems to confirm the observations made a long time ago at Vesuvius, that the white ashes are thrown out the last, and indicate the end of the eruption. In proportion as the elasticity of the vapors diminishes, the matter is thrown to a less distance; and the black rapilli, which issue the first, when the lava has ceased running, must necessarily reach farther than the white rapilli. The last appear to have undergone the action of a more intense fire.

I have now examined the exterior structure of the Peak, and the composition of its volcanic productions, from the region of the coast to the top of the Piton. I have endeavoured to render these researches interesting, by comparing the phænomena of the volcano of Teneriffe with those that are observed in other regions, the soil of which is equally undermined by subterranean fires. This

mode of viewing Nature in the universality of her relations is no doubt prejudicial to the rapidity suitable to an itinerary; but I thought, that, in a narrative, the principal end of which is the progress of physical knowledge, every other consideration ought to be subservient to those of instruction and utility. It is by isolating facts, that travellers, on every other account respectable, have given birth to so many false ideas of the pretended contrasts, which Nature offers in Africa, in New Holland, and on the ridge of the Cordilleras. The great geological phænomena are subject to the same laws, as well as the forms of plants and animals. The ties which unite these phænomena, the relations which exist between such varied forms of organized beings, are discovered only when we have acquired the habit of viewing the Globe as a great whole; and when we consider in the same point of view the composition of rocks, the forces which alter them, and the productions of the soil, in the most distant regions.

After having treated of the volcanic substances of the isle of Teneriffe, we have to solve a question intimately connected with the preceding investigation, which in these latter times has much engaged the attention of mineralogists. Does the Archipelago of the Canary islands contain any rocks of primitive or secondary formation; or is there any production observed, that has not been modified by fire? This interesting problem has

been examined by the naturalists with Lord Macartney, and by those who accompanied Captain Baudin in his voyage to the Austral lands. The opinions of these distinguished scientific men are in direct opposition to each other; and a contradiction of this nature is so much the more striking, as there is no question here of one of those geological reveries, which we are accustomed to call systems, but of a positive fact, easy to verify.

Doctor Gillan, according to the narrative of Sir George Staunton*, imagined, that he observed, between Laguna and the port of Orotava, in very deep ravines, beds of primitive rocks. This assertion, though repeated by a number of travellers, who copy each other, is not the less inaccurate. What Dr. Gillan calls somewhat vaguely, *mountains of hard ferruginous clay*, are nothing but an alluvion, which we find at the foot of every volcano. Strata of clay accompany basalts, as tufas the modern lavas. Neither M. Cordier nor myself observed in any part of Teneriffe a primitive rock, either in its natural place, or thrown out by the mouth of the Peak; and the absence of these rocks characterizes almost every island of small extent, that has an unextinguished volcano. We know nothing positive of the mountains of the Azores; but it is certain, that the island of Re-

* Voy. de Lord Macartney, t. i. p. 15.

union*, as well as that of Teneriffe, exhibits only a heap of lavas and basalts. No volcanic rock rears its head, either on the Gros Morne†, or on the volcano of Bourbon, or on the colossal pyramid of Cimandef, which is perhaps more elevated than the Peak of the Canary Islands.

It is nevertheless asserted‡, that lavas including fragments of granite have been found on the elevated plain of Retama. M. Broussonet informed me, a short time before his death, that, on a hill above Guimar, fragments of mica-slate, containing beautiful plates of specular iron had been found. I can affirm nothing respecting the accuracy of this observation, which it would be so much the more important to verify, as M. Poli, of Naples, is in possession of a fragment of rock thrown out by Vesuvius§, which I found to be a

* The Isle of Bourbon.

† Blocks of granite, thrown out probably by the ancient volcano of the Gros-Morne, are found near the source of Trois-Rivières; and this fact is so much the more worthy attention, as the neighbouring islands, known under the name of Sechelles, are formed of granitic rocks.—*Bory de St. Vincent, Voy. aux Iles d'Afrique*, t. i, p. 338; t. ii, p. 35; t. iii, p. 145 et 246.

‡ Bory St. Vincent, Essai sur les Iles Fortunées, p. 278.

§ In the valuable collection of Dr. Thomson, who resided at Naples till 1805, is a fragment of lava enclosing a real granite, which is composed of reddish feldspar with a pearly lustre like adularia, quartz, mica, hornblende, and, what is very remarkable, lazulite. But in general the masses of

real mica-slate. Every thing that tends to enlighten us with respect to the site of the volcanic fire, and the position of rocks subject to its action, is highly interesting to geology.

It is possible, that, at the Peak of Teneriffe, the fragments of primitive rocks thrown out by the mouth of the volcano were less rare than they appear to be, and are heaped together in some ravine, which may not yet have been visited by travellers. In fact, at Vesuvius, these same fragments are met with only in one single place, at the *Fossa-Grande*, where they are hidden under a thick layer of ashes. If this ravine had not long ago caught the attention of naturalists, when masses of granular limestone, and other primitive rocks, were laid bare by the rains, we might have thought them as rare at Vesuvius, as they are, at least in appearance, at the Peak of Teneriffe.

With respect to the fragments of granite, gneiss, and mica-slate, which we find on the shores of Santa Cruz and Orotava, they do not come from

known primitive rocks, I mean those which perfectly resemble our granites, our gneiss, and our mica-slates, are very rare in lavas; the substances we commonly denote by the name of granite thrown out by Vesuvius are mixtures of nepheline, mica, and pyroxene. We are ignorant whether these mixtures constitute rocks *sui generis* placed under granite, and consequently of more ancient date; or simply form either intermediate strata or veins, in the interior of the primitive mountains, the tops of which appear at the surface of the Globe.

the opposite coasts of Africa, which are calcareous, but were probably brought in ships as ballast. They no more belong to the soil where they lie, than the feldsparry lavas of Etna, which we observe in the pavements of Hamburgh and other towns of the north. The naturalist is exposed to a thousand errors, if he loses sight of the changes, which the intercourse between nations produces on the surface of the Globe. We might be led to say, that man, expatriating himself, is desirous that every thing should change country with him. Not only plants, insects, and different species of small quadrupeds, follow him across the ocean; his active industry covers the shores with rocks, that he has torn from the soil in distant climes.

If it be certain, that no enlightened observer has hitherto found at Teneriffe primitive strata, or even those trappean and ambiguous porphyries, which constitute the basis of Etna*, and of several

* The Chevalier Gioeni, who, like several mineralogists of Germany and France, distinguishes the basalts from the modern lavas, considers Etna as a mountain of porphyry, surmounted by columnar basalts, which serve, in their turn, as a basis to the feldsparry lavas. The last alone appear to be owing to the present volcano. The basalts and the porphyries belong to a system of older mountains, which cover a great part of Sicily. The porphyries of Etna are volcanic without doubt; but every rock, which owes its composition and its form to the action of fire and vapours, has not made part of a current of lavas. These observations appeared to me so much the more necessary, as some very distinguished

volcanoes of the Andes, we must not conclude from this isolated fact, that the whole of the Archipelago of the Canaries is the production of submarine fires. The island of Gomera contains mountains of granite and mica-slate *, and it is undoubtedly in these very ancient rocks, that we must here seek, as well as on all other parts of the Globe †, the centre of the volcanic action. Hornblende, sometimes pure and forming intermediate strata, at other times mixed with granite, as in the *basanites* or basalt of the ancients, may, by itself, furnish all the iron contained in the black and stony lavas. This quantity amounts in the basalt of the modern mineralogists only to 0·20, while in hornblende it exceeds 0·30.

mineralogists have recently affirmed, that the Peak of Teneriffe and Vesuvius are mountains of porphyry of Neptunian origin, and undermined by subterranean fires. The lava of *la Scala* has been described without hesitation as a particular rock, under the name of *graustein*, though it issued from the crater at a well known epocha, in 1631: some have even gone farther; they have supposed, that Somma exhibits the untouched nucleus of Vesuvius, though its stratified mass, traversed by veins filled with more recent lava, is identical with the rock constituting the actual crater, which has evidently been in a state of fusion. Somma exhibits the same leucites as abound in the greater part of the lavas of Vesuvius, and their crystals are included in a phonolite resembling that of the top of the Peak of Teneriffe.

* Note manuscrite de M. Broussonet.

† Dolomieu, in the Journ. de Phys. 1798, p. 414.

Were these granites and these mica-slates of Gomera anciently united to the chain of Atlas, as the primitive mountains of Corsica appear to be the central nucleus of Bochetta and the Apennines? This question can never be solved, till mineralogists shall have visited the islands that surround the Peak, and the mountains of Morocco covered with eternal snows. Whatever at some future day may be the result of these investigations, we could not admit with Mr. Peron*, "that in none of the Canary Islands do we meet with true granites; and that, the whole of the Archipelago being exclusively volcanic, the partisans of the Atlantis must suppose, what is equally destitute of probability, either a continent perfectly volcanic, or that only the volcanic parts of that continent were spared in the catastrophe, by which it was swallowed up."

From the information of several well instructed persons, to whom I addressed myself, I found, that there are calcareous formations in the Great Canary, Fortaventura, and Lanzerota†. I was not able to determine the nature of this secondary rock; but it appears certain, that the island of Teneriffe is altogether destitute of it; and that among its alluvial lands it exhibits only clayey

* Voyage de Découvertes aux Terres Australes, t. i, p. 24.

† At Lanzerota calcareous stone is burned to lime with a fire made of the alhulaga, a new species of thorny and arborescent sonchus.

calcareous tufa, but which alternates with volcanic breccias, and which, according to Mr. Vieyra*, contains near the village of La Rambla, at Calderas, and near Candelaria, plants, imprints of fishes, buccinites, and other fossil marine productions. M. Cordier has brought away some of this tufa, which resembles that in the environs of Naples and Rome, and contains fragments of reeds. At the Salvages, which La Pérouse took at a distance for a mass of scoriæ, even fibrous gypsum is found.

I had seen, while herbalizing between the port of Orotava and the garden of La Paz, heaps of grayish calcareous stones, of an imperfect conchoidal fracture, and analogous to that of Mount Jura and the Apennines. I was informed, that these stones were extracted from a quarry near Rambla; and that there were similar quarries near Realejo, and the mountain of Roxas, above Adexa. This information, probably not very accurate, led me into an error. As the coasts of Portugal consist of basalts covering calcareous rocks containing shells, I thought, that a trappean formation, like that of the Vicentin in Lombardy, and of Harutsch in Africa, might have

* Noticias historicas, t. i, p. 35. The Isle of France, which rises in the form of a pyramid, and in the disposition of its volcanic hills has many points of resemblance with Teneriffe, has a Neptunian plain in the quartier des Pamplemousses. The calcareous stone there is filled with madrepores. *Bory de St. Vincent*, t. i, p. 207.

extended from the banks of the Tagus and Cape St. Vincent as far as the Canary islands; and that the basalts of the Peak might perhaps conceal a secondary calcareous stone. I mentioned these ideas in a letter, which was not intended to be made public; and they have exposed me to the severe reprehension of a naturalist, according to whom every volcanic island is only an accumulation of lavas and scoriæ, and who admits no fact contrary to his own theory of volcanoes*.

Though Teneriffe belongs to a group of islands of considerable extent, the Peak exhibits nevertheless all the characters of a mountain placed on a solitary islet. As at St. Helena, the lead finds no bottom† at a little distance from the ports

* Examination of certain geological opinions of M. de Humboldt, by Mr. G. A. De Luc (*Journ. de Phys.* t. 50, P. 1, p. 114). This memoir, in which we recognise an excellent observer, is the continuation of another against Mr. Kirwan, who thinks, that the lavas of Vesuvius repose on the calcareous beds of the Apennines. Ibid. vol. xlix, p. 23. According to the *Theory of Volcanoes*, given by Mr. De Luc, it is *impossible*, that a real lava should contain fragments of vegetable substances. Our collections, however, contain pieces of trunks of palm-trees, enclosed and penetrated by the very liquid lava of the Isle of Bourbon. See the interesting memoir of M. de Fleuriau, *l. c.* vol. lx, p. 441.

† Voy. de l'Isis, vol. i, p. 287; Voy. de Marchand, t. i, p. 542.

of Santa Cruz, Orotava, and Garachico. The ocean, as well as the continents, has its mountains and its plains; and, if we except the Andes, the volcanic cones are formed every where in the regions of the Globe.

As the Peak rises amid a system of basalts and old lava, and as the whole part which is visible above the surface of the waters exhibits burnt substances, it has been supposed, that this immense pyramid is the effect of a progressive accumulation of lavas; or that it contains in its centre a nucleus of primitive rocks. Both of these suppositions appear to me improbable. I think that there as little existed mountains of granite, gneiss, or primitive calcareous stone, where we at present see the tops of the Peak, of Vesuvius, and of Etna, as in the plains where almost in our own time has been formed the volcano of Jorullo, which is more than a third of the height of Vesuvius. On examining the circumstances, which accompanied the formation of the new island in the Archipelago of the Azores *;

* Sabrina island. See the letter of Captain Tillard to Sir Joseph Banks, *Philos. Trans for* 1812, p. 152. At Sabrina island, near St. Michael's, the crater opened at the foot of a solid rock, of almost a cubical form. This rock, terminated by a small elevated plain perfectly even, is more than two hundred toises in breadth. Its formation was anterior to that of the crater, into which, a few days after its opening, the sea made an irruption. At Kameni, the smoke was not

on carefully reading the minute and ingenuous narrative, which the Jesuit Bourguignon gave of the slow appearance of the islet of the little Kameni, near Santorino; we find, that these extraordinary eruptions are generally preceded by a swelling of the softened crust of the Globe. Rocks appear above the waters before the flames force their way, and lava can issue from the crater: we must distinguish between the nucleus raised up, and the mass of lavas and scoriæ, which successively increase its dimensions.

It is true, in all the revolutions of this kind, which have taken place since the time that their history has been written, the perpendicular height of the stony nucleus appears never to have exceeded one hundred and fifty or two hundred toises; even taking into the account the depth of the sea, the bottom of which had been lifted up: but when we are considering the great effects of nature, and the intensity of its forces, it is not the bulk of the masses, that ought to stop the geologist in his speculations. Every thing indi-

even visible till twenty six days after the appearance of the raised rocks. *Phil. Trans.* vol. xxvi, p. 69 and 200; vol. xxvii, p. 353. All these phænomena, on which Mr. Hawkins collected very valuable observations during his abode at Santorino, are unfavorable to the idea commonly entertained of the origin of volcanic mountains, which ascribes them to a progressive accumulation of liquified matter, and the diffusion of lavas issuing from a central mouth.

cates, that the physical changes, of which tradition has preserved the remembrance, exhibit but a feeble image of those gigantic catastrophes, which have given mountains their present form, changed the positions of the rocky strata, and buried seashells on the summit of the higher Alps. It was undoubtedly in those remote times, which preceded the existence of the human race, that the raised crust of the Globe produced those domes of trappean porphyry, those hills of isolated basalt on vast elevated plains, those solid nuclei which are clothed in the modern lavas of the Peak, of Etna, and of Cotopaxi. The volcanic revolutions have succeeded each other after long intervals, and at very different periods: of this we see the vestiges in the transition mountains, in the secondary strata, and in those of alluvion. Volcanoes of earlier date than the sandstone and calcareous rocks have been for ages extinquished; those which are yet in activity are in general surrounded only with breccias and modern tufas; but nothing hinders us from admitting, that the archipelago of the Canaries may exhibit some real rocks of secondary formation, if we recollect, that subterraneous fires have been there rekindled in the midst of a system of basalts and very ancient lavas.

I should wander too long from the principal object of my researches, were I to pursue a subject, in which mere conjecture supplies the place

of geological fact. From those dark times, when the elements, subjected to the same laws, had not yet attained their present equilibrium, I come back to a period less tumultuous, nearer our own age, and on which tradition and history may throw some light. We seek in vain in the Periplus of Hanno or of Scylax the first notions written on the eruptions of the Peak of Teneriffe. Those navigators sailed timidly along the coast, anchoring every evening in some bay, and had no knowledge of a volcano distant fifty six leagues from the coast of Africa. Hanno nevertheless relates, that he saw torrents of light, which seemed to fall on the sea; that every night the coast was covered with fires; and that the great mountain, called the *Car of the Gods*, had appeared to throw up sheets of flame, which rose even to the clouds. But this mountain, placed to the north of the island of the Gorilli*, formed the

* It was in this island, that the Carthaginian admiral saw, for the first time, a large species of apes of human form, the Gorilli. He describes them like women, their body covered entirely with hair, and very mischievous, because they defended themselves with their teeth and nails. He boasts of having flayed three of them to preserve their skins. M. Gosselin places the isle of the Gorilli at the mouth of the river Nun; but, according to this account, the lake, near which Hanno saw a multitude of elephants feeding, should be in the latitude of thirty five and a half, almost at the northern extremity of Africa. *Recherches sur a Géographie des Anciens*, t. i, p. 74 et 98.

western extremity of the chain of Atlas; and it is also very uncertain, whether the flames seen by Hanno were the effect of some volcanic eruption, or whether they should be attributed to the custom, common to so many nations, of setting fire to the forests and dry grass of the savannahs. In our own days similar doubts were entertained by the naturalists, who, in the voyage of d'Entrecasteaux, saw the island of Amsterdam covered with a thick smoke*. On the coast of the Caraccas, trains of reddish fire, fed by the burning grass, exhibited to me, for several nights, the delusive aspect of a current of lava, descending from the mountains, and dividing itself into several branches.

Though the journals of Hanno and Scylax, in the state in which they have reached us, contain no passage, which we can reasonably apply to the Canary islands, it is however very probable, that the Carthaginians, and even the Phœnicians, had some knowledge† of the Peak of Teneriffe.

* *Voy. de Labillardière*, t. i, p. 112. *Voy. de d'Entrecasteaux*, t. i, p. 45.

† See a Treatise by Mr. Ideler, inserted in my *Views of Nature*, t. i, p. 141; and Gosselin, *Recherches*, t. i, p. 135—159. One of the most distinguished writers of Germany, Mr. Heeren, thinks, that the Fortunate Islands of Diodorus Siculus were Madeira and Porto Santo. *Afrika*, t. i, p. 124. *Malte-Brun, Histoire de la Géographie*, p. 76, 90 et 194.

In the time of Plato and Aristotle, vague notions of it had reached the Greeks, who considered the whole of the coast of Africa, beyond the Pillars of Hercules, as thrown into disorder by the fire of volcanoes*. The Place of the Blessed, which was sought first in the north, beyond the Riphean mountains, among the Hyperboreans †, and then to the south of Cyrenaica, was situate in regions that were considered as toward the west, where the world known to the ancients terminated. The name of Fortunate Islands had long been as vague a signification, as that of *Dorado* among the first conquerors of America. Happiness was thought to reside at the end of the Earth, as we seek for the most exquisite enjoyments of

* *Arist. Mirab. Auscult. (ed. Casaub.)* p. 704. Solinus says of Atlas, *vertex semper nivalis lucet nocturnis ignibus;* but this Atlas, which, like the mountain Meru of the Hindoos, exhibits a mixture of true ideas and mythological fictions, was not situate in one of the islands of the Hesperides, as the Abbé Vieyra admits, and after him several travellers, who have described the Peak of Teneriffe (*Vieyra*, t. i, p. 225; *Bory de St. Vincent*, p. 395). The following passages leave no doubt on this head. *Herod.* iv, 184; *Strabo*, xvii (*ed. Falconer*, t. ii, p. 1167); *Mela*, iii, 10; *Pliny*, v. 1; *Solinus*, i. 24; and even *Diod. Sic.* iii (*ed. Wess.* t. i, p. 221).

† *Mannert. Geogr. der Griechen*, t. iv, s. 57. The idea of the happiness, of the great civilization, and of the riches of the inhabitants of the north, was common to the Greeks, to the people of India, and to the Mexicans.

the mind in an ideal world beyond the limits of reality.

We must not be surprised, that, previous to the time of Aristotle, we find no accurate notion respecting the Canary islands, and the volcanoes they contain, among the Greek geographers. The only nation, whose navigations extended toward the west and the north, the Carthaginians, were interested in throwing a veil of mystery over those distant regions. While the senate of Carthage was averse to any partial emigration, it pointed out these islands as a place of refuge in times of trouble and public misfortune; they were to the Carthaginians, what the free soil of America is become to Europeans amidst their religious and and civil dissensions.

The Canaries were not better known to the Romans till eighty-four years before the reign of Octavian. A private individual was desirous of executing the project, which wise foresight had dictated to the senate of Carthage. Sertorius, conquered by Sylla, wearied with the tumult of arms, looks out for a safe and peaceable retreat. He chooses the Fortunate Islands, of which a delightful picture had been drawn for him on the coasts of Bætica. He carefully combines the notions he can acquire from travellers; but in the little that has been transmitted to us of these notions, and in the more minute descriptions of Sebosus and Juba, there is no mention of volcanoes

or volcanic eruptions. Scarcely can we recognise the isle of Teneriffe, and the snows with which the summit of the Peak is covered in winter, in the name of *Nivaria*, given to one of the *Fortunate Islands*. Hence we might conclude, that the volcano at that time threw out no flames; if it were permitted to interpret the silence of a few authors, whom we know only by short fragments, or dry nomenclatures. The naturalist vainly seeks in history for documents of the first eruptions of the Peak, he no where finds any but in the language of the Guanches, in which the word Echeyde * denotes at the same time Hell and the volcano of Teneriffe.

Of all the written testimonies, the oldest I have found of the activity of this volcano dates from the beginning of the sixteenth century. It is contained in the narrative of the voyage † of

* The same mountain bore the name of *Aya-dyrma*, in which Horn (*de Originib. Americ.* p. 155 and 185) imagines he finds the ancient denomination of Atlas; which, according to Strabo, Pliny, and Solinus, was Dyris. This etymology is very doubtful; but in not giving more importance to the vowels, than they have among the people of the East, we find Dyris almost complete in the word Daran, by which the Arabian geographers denote the eastern part of Mount Atlas.

† Nec silendum puto de insula Teneriffæ, quæ et eximie colitur, & inter orbis insulas est eminentior. Nam cælo sereno eminus conspicitur; adeo ut qui absunt ab ea ad leucas hispanas sexaginta vel septuaginta non difficulter eam intueantur. Quod cernatur a longe id efficit acuminatus lapis adamantinus,

Aloysio Cadamusto, who landed at the Canaries in 1505. This traveller was witness of no eruptions, but he positively affirms, that, like Etna, this mountain burns without interruption, and that the fire has been seen by Christians retained in slavery by the Guanches of Teneriffe. The Peak therefore was not at that time in the state of repose, in which we find it at present; for it is certain, that no navigator or inhabitant of Teneriffe, has seen issue from the mouth of the Peak, I will not say flames, but even any smoke that was visible at a distance. Perhaps it is to be wished, that the funnel of the Caldera may open anew; the lateral eruptions would thus be rendered less violent, and the whole group of islands would have less to fear from the effects of earthquakes *.

instar pyramidis, in medio. Qui metiti sunt lapidem aiunt altitudine lucarum quindecim mensuram excedere ab imo ad summum verticem. Is lapis jugiter flagrat, instar Ætnæ montis; id affirmant nostri Christiani, qui capti aliquando hæc animadvertêre. *Aloysii Cadamusti Navigatio ad Terras Incognitas*, c. 8.

* At Teneriffe the shocks have hitherto been very inconsiderable, and limited to a small extent of ground. The same thing has been observed at the Isle of Bourbon, and almost every where at the foot of burning volcanoes. At Naples, earthquakes precede the eruptions of Vesuvius, they cease when the lava begins to flow, and are in general very feeble in comparison of those felt on the slope of the calcareous Apennines.

I have heard the question discussed at Orotava, whether it can be admitted, that in the lapse of ages the Peak will begin again to act. In a matter so doubtful, analogy alone can serve as a guide. Now according to the report of Braccini, the interior of the crater of Vesuvius was covered with shrubs in 1611. Every thing then indicated the greatest tranquillity; and nevertheless twenty years after, the same gulf, which seemed transformed into a shadowy vale, threw out sheets of fire, and an enormous quantity of ashes. Vesuvius resumed in 1631 the same activity it had in 1500. In the same manner it is possible, that the crater of the Peak may change its appearance at some future period. It is a solfatara like the tranquil solfatara of Puzzuoli; but it is placed on the summit of a volcano yet in activity.

The eruptions of the Peak have been very rare for two centuries past, and these long intervals appear to characterize volcanoes highly elevated. The smallest of the whole, Stromboli, is almost always burning. At Vesuvius, the eruptions are already rarer, though still more frequent than those of Etna and the Peak of Teneriffe. The colossal summits of the Andes, Cotopaxi, and Tungurahua, scarcely have an eruption once in a century. We might say, that in active volcanoes the frequency of the eruptions is in the inverse ratio of the height and the mass. The Peak also had seemed extinguished during ninety-two years, when, in

1798, it made its last eruption by a lateral opening formed in the mountain of Chahorra. In this interval Vesuvius had sixteen eruptions.

I have observed in another place *, that the whole of the mountainous part of the kingdom of Quito may be considered as an immense volcano, occupying more than seven hundred square leagues of surface, and throwing out flames by different cones, known under the particular denominations of Cotopaxi, Tungurahua, and Pichincha. In like manner, the whole group of the Canary islands is placed, as it were, on the same submarine volcano. The fire makes its way sometimes by one and sometimes by another of these islands. Teneriffe alone contains in its centre an immense pyramid terminated by a crater, and throwing out, from one century to another, lava by its flanks. In the other islands, the different eruptions have taken place in various parts; and we no where find those isolated mountains, to which the volcanic effects are restrained. The basaltic crust, formed by ancient volcanoes, seems every where undermined; and the currents of lava, seen at Lanzerota and Palma, remind us by every geological affinity of the eruption, which took place in 1301 at the isle of Ischia, amid the tufas of Epomeo.

The following is a statement of the volcanic

* Géograph. Végét. p. 130.

phænomena, of which the historians of the Canary islands have preserved the remembrance since the middle of the sixteenth century.

Year 1558.

At the period when the island of Teneriffe was ravaged for the first time by the plague brought from the Levant, a volcano burst open, on the 15th of April, in the isle of Palma, near a spring in the Partido de los Llanos. A mountain rose from the earth; and formed a crater at the top, which threw out a current of lava a hundred toises in breadth, and more than two thousand five hundred in length. The lava flowed into the sea, and, raising the temperature of the water, destroyed the fish * at great distances around.

Year 1646.

The 13th of November, a volcanic mouth opened in the island of Palma, near Tigalate. Two others were formed on the seashore. The lavas which issued from these crevices dried up the celebrated spring of Furcaliente, or Fuente Santa; the mineral waters of which attracted the visits of the diseased, who flocked thither even from Europe. According to a popular tradition, the erup-

* This same phænomenon took place in 1811, near the Azores, when the volcano of Sabrina opened at the bottom of the ocean. The calcined skeleton of a shark was found in the inundated and extinguished crater.

tion ceased in a very extraordinary manner. The image of our Lady of the Snows, of Santa Cruz, was carried to the mouth of the new volcano, and immediately there fell such an immense quantity of snow, that the fire was extinguished. In the Andes of Quito, the Indians think they have observed, that an abundance of snow water filtrating into volcanoes increases their activity.

Year 1677.

Third eruption in the isle of Palma. The mountain de Las Cabras threw out scoriæ and ashes through a multitude of small mouths, which were formed in succession.

Year 1704.

On the 31st of December, the Peak of Teneriffe formed a lateral eruption in the plain De los Infantes, above Icore, in the district of Guimar. Tremendous earthquakes preceded this eruption. On the 5th of January 1705, a second opening took place in the ravine of Almerchiga, a league from Icore. The lavas were so abundant, that the whole valley of Fasnia, or Areza, was filled up. This second mouth ceased its eruption on the 13th of January. A third was formed the 2d of February, in the Cannada de Arafo. The lavas divided into three currents, and threatened the village of Guimar; but they were stopped in the valley of Melosar by a chain of rocks, which

formed an insuperable obstacle to their passage. During these eruptions, the town of Orotava, separated from the new mouths by a very narrow dyke, felt strong shocks.

Year 1706.

On the 5th of May another lateral eruption of the Peak of Teneriffe took place. The mouth opened on the south of the port of Garachico, which was then the finest and most frequented harbour in the island. This opulent and populous city was built on the edge of a forest of laurels, in a very picturesque situation. Two currents of lava destroyed it in a few hours, not a single edifice being left standing. The port, which had already suffered in 1645 by the accumulation of sand and mud caused by a great inundation, was so filled up, that the lavas formed a promontory in the midst of it. In the environs of Garachico, the surface of the ground changed its appearance. Hills arose in the plain; the springs became dry; and the rocks, shaken by frequent earthquakes, remained naked, without vegetation, and without mould. The fishermen only retained their affection for their native spot. Intrepid, like the inhabitants of the Torre del Greco, they rebuilt a small village on the masses of scoriæ, and on the vitrified rock.

Year 1730.

On the 1st of September a dreadful revolution

broke up the ascent of the Isle of Lanzerota. A new volcano opened at Temanfaya. The lavas which flowed, and the earthquakes which accompanied the eruption, destroyed a considerable number of villages; among which were the three old Guanche townships of Tingafa, Macintafe, and Guatisca. The shocks lasted till 1736; and the greater part of the inhabitants of Lanzerota fled to the island of Fortaventura. During this eruption, which has been noticed in the preceding chapter, a column of thick smoke was seen to issue from the sea. Pyramidal rocks rose above the surface of the waters; and these new rocks, gradually extending, became a part of the island itself.

Year 1798.

On the 9th of June there was a lateral eruption of the Peak of Teneriffe, by the flanks of the mountain of Chahorra, or Venge*, in a place entirely uncultivated, to the south of Icod, near the village of Guia, the ancient Isora. This mountain, backed by the Peak, was at all times considered as an extinguished volcano. Though formed of solid matter, it is with respect to the Peak, what Monte Rosso, which appeared in 1661,

* The slope of the mountain of Venge, on which the eruption took place, is called Chazajanne. See Nicolas de Segundo de Franqui, in Cavanilles y Hergen, Annales de Historia natural, t. i, p. 298.

and the Boche nuove of 1794, are to Vesuvius and Etna. The eruption of Chahorra lasted three months and six days. The lavas and scoriæ were thrown out by four mouths, placed in the same line. When the lava had gained three or four toises in height, it advanced three feet every hour. This eruption took place but a year before my arrival at Teneriffe, and had left a durable impression among the inhabitants. I saw at the house of M. Legros, at Durasno, a drawing of the mouths of the Chahorra, which he had taken on the spot. Don Bernardo Cologan had visited these mouths eight days after they were opened, and he had described the principal phænomena of this eruption in a memoir, of which he gave me a copy to insert in the narrative of my travels. Thirteen years having elapsed since that period, and M. Bory de St. Vincent having preceded me in the publication of this memoir, I refer the reader for it to his interesting *Essay on the Fortunate Islands* *. I shall only mention some circumstances respecting the height, to which very considerable fragments of rocks were projected by the mouths of the Chahorra. Mr. Cologan † reckoned

* Bory de St. Vincent, p. 296.

† "Three of these stones," says M. Bory de St. Vincent, "took from twelve to fifteen seconds to rise till they were out of sight and fall back to the ground." If such was the observation of Mr. Cologan, the result of the calculation

from twelve to fifteen seconds during the fall of these stones, that is to say, beginning to count from the moment they had reached the maximum of their height. This curious experiment proves, that the mouth projected rocks upwards of three thousand feet.

The whole of the eruptions recorded in this chronological statement belong solely to the three islands of Palma, Teneriffe, and Lanzerota*. It is probable, that, previous to the sixteenth century, the other islands experienced also the effects of the volcanic fire. Some vague accounts were given me of an extinguished volcano in the centre of the isle of Ferro, and of another in the Great Canary, near Arguineguin. But it would be curi-

would differ from that I have given; but the observer expressly says, in the manuscript in my possession: "De noche se observò con relox en mano y a muy corta distancia de la tercera bocca del volcan de Chahorra, el tiempo que desde su mas alto punto de elevacion hasta perderlas de vista en su caida, gastaban las piedras mas faciles de distinguir y de tres conque se hizo la experiencia, dos cayeron en cliez segundas cada una y la otra en quinze." Mr. Cologan observes, that the duration of the fall was even something more than fifteen seconds, because he could not keep the stones in sight till they touched the ground. This kind of observation is susceptible of great precision, as I was convinced from similar experiments, which I made during the eruption of Vesuvius in 1805.

* Vieyra, Noticias, t. ii, p. 404; t. iii, p. 151, 238, 352, 356, and 516.

ous to know whether traces of subterranean fire are found in the calcareous formations of Fortaventura, or in the granites and mica-slates of Gomera.

The merely lateral action of the Peak of Teneriffe is a geological phænomenon, so much the more remarkable, as it contributes to make mountains, which are backed by the principal volcano, appear isolated. It is true, that in Etna and Vesuvius the great flowings of the lavas do not proceed from the crater itself, and that the abundance of melted matter is generally in the inverse ratio of the height, at which the opening, that ejects the lava, takes place. But at Vesuvius and Etna a lateral eruption constantly finishes by flashes of flame and by ashes, which issue from the crater, that is, from the summit of the mountain. At the Peak, this phænomenon has not taken place for ages: and yet recently, in the eruption of 1798, the crater remained quite inactive. Its bottom did not sink in, while at Vesuvius, as Mr. von Buch ingeniously observes, the greater or less depth of the crater is an infallible indication of the proximity of a new eruption.

I might terminate these geological sketches by discussing the nature of the combustible, which feeds, for so many thousands of years, the fire of the Peak of Teneriffe; I might examine whether it be sodium or potassium, the metallic basis

of some earth, carburet of hydrogen, or pure sulphur combined with iron, that burns in the volcano; but wishing to limit myself to what may be the object of direct observation, I will not take upon me to solve a problem, for which we have not yet sufficient data. We are ignorant, whether we should conclude from the enormous quantity of sulphur contained in the crater of the Peak, that it is this substance which keeps up the heat of the volcano; or whether the fire, fed by a combustible of an unknown nature, effects merely the sublimation of the sulphur. What we learn from observation is, that in craters which are still burning sulphur is very rare; while all the ancient volcanoes finish by remaining true sulphur pits. We might presume, that in the former the sulphur is combined with oxygen, while in the latter it is merely sublimed; for nothing hitherto authorises us to admit, that it is formed in the interior of volcanoes, like ammonia and the neutral salts. When we were yet unacquainted with sulphur, but as disseminated in the muriatiferous gypsum, and in the Alpine limestone, we were almost obliged to suppose, that in every part of the Globe the volcanic fire acted on rocks of floetz or secondary formation; but recent observations have proved, that sulphur exists in great abundance in those primitive rocks, which so many phænomena indicate as the centre of the volcanic action. Near Alausi, on the summit of the Andes of Quito, I found an

immense quantity in a bed of quartz, which formed a layer of mica-slate*; and this fact is so much the more important, as it is in strict conformity with the observation of those fragments of ancient rocks, which are thrown out untouched by the volcanoes.

We have just considered the isle of Teneriffe under mere geological points of view; we have seen the Peak towering amid fractured strata of basalt and mandelstein; let us examine how these melted matters have been gradually adorned with vegetable clothing, what is the distribution of plants on the steep declivity of the volcano, and what is the aspect or physiognomy of vegetation in the Canary islands.

* In geognosy we must distinguish seven formations of sulphur, which are of a very different relative antiquity. The first belongs to the mica-slate (Cordilleras of Quito); the second, to the transition gypsum (Bex in Switzerland); the third to the trappean porphyries (Antisana in America, Mont Serrat in the archipelago of the smaller Antilles, Mont d'Or in France); the fourth, to the Alpine limestone (Sicily); the fifth, to the muriatiferous gypsum, placed between the sand-stone and the Alpine limestone (Thuringia); the sixth, to the gypsum which is more recent than chalk (Montmartre, near Paris); and the seventh, to clayey alluvions (Venejuelo, Lower Orinoco, Mexico). It is scarcely necessary to observe, that, in this nomenclature, those small masses of sulphur, which are not contained in strata, but in the veins that traverse rocks of different formations, are left out of the question.

In the northern part of the temperate zone, the cryptogamous plants are the first, that cover the stony crust of the Globe. The lichens and mosses, that display their foliage beneath the snows, are succeeded by gramina, and other phanerogamous plants. This order of vegetation is different on the borders of the torrid zone, and in the countries between the tropics. We there find, it is true, whatever some travellers may have asserted, not only on the mountains, but also in humid and shady places, almost on a level with the ocean, funaria, dicranum, and bryum; and these genera, among their numerous species, exhibit several, which are common to Lapland, the Peak of Teneriffe, and the Blue Mountains of Jamaica*. Nevertheless, in general, it is not by mosses and lichens that vegetation in the countries near the tropics begins. In the Canary islands, as well as in Guinea, and on the rocky coasts of Peru, the first vegetables, that prepare the mould for others, are the succulent plants; the leaves of which, provided with an infinite number of orifices† and cutaneous

* This extraordinary fact, of which we shall speak hereafter, was first observed by Mr. Swarz. It was confirmed by the careful examination, which Mr. Willdenow made of our herbals, especially of the collection of cryptogamous plants, which we gathered on the tops of the Andes, in a region of the world where organised beings totally differ from those of the rest of the old continent.

† The bark pores of M. Decandolle, discovered by Gleichen, and figured by Hedwig.

vessels, deprive the ambient air of the water it holds in solution. Fixed in the crevices of volcanic rocks, they form, as it were, that first layer of vegetable earth, with which the currents of lithoid lava are clothed. Wherever these lavas are scorified, and where they have a shining surface, as in the basaltic mounds to the north of Lanzerota, the unfolding of vegetation is extremely slow, and many ages may roll away before shrubs can take root. It is only when lavas are covered with tufa and ashes, the volcanic islands lose that appearance of nudity which marks their origin, and deck themselves with a rich and brilliant vegetation.

In its present state, the island of Teneriffe, the *Chinerfe** of the Guanches, exhibits five zones of plants†, which we may distinguish by the names of region of vines, region of laurels, region of pines, region of the retama, and region of grasses.

* Of Chinerfe the Europeans have formed, by corruption, Tchineriffe and Teneriffe.

† I have partly sketched this picture of the vegetation of the Canaries from the manuscript notes of M. Broussonet. When I published my first "Essay on the Geography of the Equinoctial Plants of the New World," I begged this distinguished naturalist, who had long resided at Mogadore, in the empire of Morocco, and at Santa Cruz, in Teneriffe, to communicate to me his ideas relative to the geographical distribution of plants in those countries. He yielded to my entreaty with that complaisance and urbanity, which he constantly exercised in his communications with learned foreigners.

These zones are arranged in stages, one above the other, and occupy, on the steep declivity of the Peak, a perpendicular height of 1750 toises; while fifteen degrees farther north, on the Pyrenees, the snows already descend to thirteen or fourteen hundred toises of absolute elevation. If the plants of Teneriffe do not reach the summit of the volcano, it is not because the perpetual snows*, and

* Though the Peak of Teneriffe is covered with snow during the winter months only, it is nevertheless possible, that the volcano reaches the limit of the perpetual snows corresponding to its latitude, and that the total absence of the snows in summer is owing to the isolated situation of the mountain in the midst of the seas, to the frequency of the ascending hot winds, or the elevated temperature of the ashes of the Piton: but we are unable to solve these doubts, in the present state of our knowledge. From the parallel of the mountain of Mexico to that of the Pyrenees and the Alps, between the 20th and the 45th degrees, the curve of the perpetual snows has not been determined by any direct measure; and as an infinite number of these curves may be traced through the small number of points which are known to us under the latitudes of 0°, 20°, 45°, 62°, and 71° north, calculation is a very imperfect substitute for observation. Without advancing any thing very positive, we may say, that it is probable in 28° 17′ the limit of the snows is above 1900 toises. From the equator, where the snows begin at 2460 toises, that is near the height of Mont Blanc, to the twentieth of latitude, consequently to the limits of the torrid zone, the snows descend only a hundred toises; now ought we to admit, that eight degrees farther, and in a climate which still bears almost the character of a climate of the tropics, this line already lowers four hundred toises? Supposing even a lowering in arithmetical progression

the cold of the surrounding atmosphere, lay down limits which they cannot pass; it is the scorified lava of the Malpays, the powdered and barren pumice stone of the Piton, which impede the migration of the plants toward the brink of the crater.

from the twentieth to the forty fifth degree of latitude, a supposition which is contrary to known facts (*Rec. d'Obs. astron.*, vol. i, p. 134), the perpetual snows would not begin under the parallel of the Peak but at the height of 2050 toises above the level of the Ocean, consequently 550 toises higher than on the Pyrenees and in Switzerland. This result is supported also by other considerations. The mean temperature of the stratum of air, with which the snows are in contact during the summer, is, on the Alps, a few degrees below the point of congelation, and under the equator, a few degrees above it (*l. c. p.* 137). Admitting that, at 28 degrees and a half, this temperature is 0, we find according to the law of the decrement of heat, reckoning 98 toises to each centesimal degree, that the snows ought to exist at the height of 2058 toises above a plain, the mean temperature of which is 21 degrees, and consequently equal to that of the coasts of Teneriffe. This number is almost identical with that deduced from the hypothesis of a diminution in arithmetical progression. One of the high tops of the Sierra Nevada of Grenada, the Pico de Veleta, the absolute height of which is 1781 toises, is perpetually covered with snows; but the inferior limits of these snows not having been measured, this mountain, in the latitude of 37° 10′, gives us no information respecting the problem we wish to solve. With respect to the position of the volcano of Teneriffe, in the centre of an island of little extent, it does not appear, that this circumstance can cause a rising of the curve of the perpetual snows. If in islands the winters are less rigorous, the sum-

The first zone, that of the vines, extends from the seashore to two or three hundred toises of height; it is that which is most inhabited, and the only part carefully cultivated. In these low regions, at the port of Orotava, and whereve

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mers are less scorching; and it is not so much on the mean temperature of the whole year, as on that of the summer months, that the height of the snows depends. On Etna the snows begin at 1500 toises, and even a little below; which is extraordinary enough for a summit placed in 37 degrees and a half of latitude.

Towards the polar circle, where the heats of summer are tempered by the fogs that rise continually above the Ocean, the difference between the islands on the coasts and the interior of the country becomes extremely perceptible. In Iceland, for example, on the Osterjoeckull, in the sixty fifth degree of latitude, the perpetual snows descend to four hundred and eighty two toises; while in Norway, in the sixty seventh, far from the coasts, in situations where the winters are much more rigorous, and where consequently the mean temperature of the year is less than in Iceland, the snows descend only to six hundred toises of height (*Leopold von Buch*, in the *Ann. of Gilb.* 1812, t. ii, p. 37 and 43). From these considerations it appears probable enough, that Bouguer and Saussure were deceived, when they admitted, that the Peak of Teneriffe reaches the constant inferior limit of the snows (*Figure de la terre*, p. 48, and *Voy. dans les Alpes*, t. iv, p. 103). We find this term for latitude 28° 17′ at least at 1950 toises high, even in calculating it by interpolation between Etna and the volcanoes of Mexico. This matter will be made entirely clear, when we shall have measured the western part of Atlas, which near Morocco, in thirty degrees and a half of latitude, is covered with perpetual snows.

the winds have free access, the centigrade thermometer stands in winter, in the months of January and February, at noon, between fifteen and seventeen degrees; and the strongest heats of the summer do not exceed twenty-five or twenty-six degrees: they are consequently five or six degrees below the extremes, which the thermometer annually reaches at Paris, Berlin, and Petersburgh. These results are taken from the observations made by Mr. Savaggi from 1795 to 1799. The mean temperature of the coasts of Teneriffe appears at least to rise to twenty one degrees (16·8° Reaumur); and their climate holds the medium between the climate of Naples, and that of the torrid zone. At the island of Madeira, the mean temperatures of the months of January and August are, according to Heberden, from 17·7° to 23·8°; while at Rome they rise to 5·6° and 26·2°. But notwithstanding the extreme analogy observable between the climates of Madeira and Teneriffe, the plants of the first of these islands are generally less delicate to cultivate in Europe, than the plants of Teneriffe. The cheiranthus longifolius of Orotava, for instance, freezes at Montpellier, according to the observation of M. Decandolle; while the cheiranthus mutabilis of Madeira passes the winter there in the open ground. The heats of summer are of less continuance at Madeira, than at Teneriffe.

The region of the vines exhibits, among its vegetable productions, eight kinds of arborescent euphorbia; mesembrianthema, which are multiplied from the Cape of Good Hope to the Peloponnesus; the cacalia kleinia, the dracæna, and other plants, which in their naked and tortuous trunks, in their succulent leaves, and their tint of blueish green, exhibit features distinguishing the vegetation of Africa. It is in this zone, that the date tree, the plantain, the sugar cane, the India fig, the arum colocasia, the root of which furnishes the lower class with a nutritive fecula, the olive tree, the fruit trees of Europe, the vine, and corn are cultivated. The wheat is reaped from the end of March to the beginning of May: and the culture of the breadfruit tree of Otaheite, that of the cinnamon tree of the Moluccas, the coffee tree of Arabia, and the cocoa tree of America, have been tried with success. On several points of the coast, the country assumes the character of a tropical landscape; and we recognise, that the region of the palms extends beyond the limits of the torrid zone. The chamærops and the date tree flourish in the fertile plains of Murviedro, on the coasts of Genoa, and in Provence, near Antibes, between the thirty-ninth and forty-fourth degrees of latitude: a few trees of the latter species, planted within the walls of the city of Rome, resist even a cold of 2·5° below the freezing point. But if the south of Europe does not

yet but feebly share in the gifts lavished by Nature on the zone of palms, the isle of Teneriffe, placed under the parallel of Egypt, southern Persia, and Florida, is already decorated with the greater part of the vegetable forms, that increase the majesty of the landscape in regions near the equator.

On reviewing the different tribes of indigenous plants, we regret the not having found trees with small pinnated leaves, and arborescent gramina. No species of the numerous family of the sensitive plants has pushed its migrations as far as the archipelago of the Canary islands, while on both continents they have been discovered as far as the thirty-eighth and fortieth degrees of latitude. In America the schranckia uncinata of Willdenow * advances even to the forests of Virginia; in Africa the gum-dropping acacia vegetates on the hills of Mogadore: in Asia, to the west of the Caspian Sea, Mr. von Biberstein saw the plains of Shirvan covered with the acacia stephaniana. If we more carefully examine the plants of the islands of Lanzerota and Fortaventura, which are nearest the coasts of Morocco, we shall perhaps find a few mimosas among so many other plants of the African Flora.

The *second zone*, that of the laurels, contains the woody part of Teneriffe; this is the region of

* Mimosa horridula. Michaux.

the springs that rise up amidst a turf always verdant, and never parched with drought. Lofty forests crown the hills, that lead to the volcano, and in them find four species of laurel *, an oak nearly resembling the quercus Turneri † of the mountains of Thibet, the visnea mocanera, the myrica faya of the Azores, a native olive (olea excelsa), which is the largest tree of this zone, two species of sideroxylon, the leaves of which are extremely beautiful, the arbutus callicarpa, and other evergreen trees of the family of myrtles. Bindweeds, and an ivy very different from that of Europe (hedera canariensis) entwine the trunks of the laurels; at their feet vegetate a numberless quantity of ferns ‡, of which three species § alone descend as low as the region of the vines. The soil, covered with mosses and a tender grass, is enriched with the flowers of the golden campanula, the chrysanthemum pinnatifidum, the Canary mint, and several bushy species of hypericum ‖. Plantations of wild and grafted chesnut

* Laurus indica, l. fœtens, l. nobilis, and l. Til. With these trees are mingled the ardisia excelsa, rhamnus glandulosus, erica arborea, and e. texo.

† Quercus canariensis, Broussonet. (*Willd. Enum. Plant. Hort. Berol.* 1809, p. 975.)

‡ Woodwardia radicans, asplenium palmatum, a. canariensis, a. latifolium, notholæna subcordata, trichomanes canariensis, t. speciosum, and davallia canariensis.

§ Two acrostichums and the ophyoglossum lusitanicum.

‖ Hypericum canariense, h. floribundum, and h. glandulosum.

trees form a large border around the region of the springs, which is the greenest and most agreeable of the whole.

The *third zone* begins at nine hundred toises of absolute height, where the last group of arbutus, of myrica faya, and that beautiful heath known to the natives under the name of texo, appears. This zone, four hundred toises in breadth, is entirely filled by a vast forest of pines, among which mingles the juniperus cedro of Broussonet. The leaves of these pines are very long, stiff, and sprout sometimes by pairs, but oftener by threes in one sheath. As we had no opportunity of examining the fructification, we cannot say whether this species, which has the appearance of the Scotch fir, is really different from the eighteen species of pines, with which we are already acquainted on the old continent. A celebrated botanist, who by his excursions has rendered great services to the botanical geography of Europe, M. Decandolle, thinks, that the pine of Teneriffe is equally distinct from the pinus atlantica of the neighbouring mountains of Mogadore, and from the pine of Aleppo *, which belongs to the basin of the

* Pinus halepensis. Mr. Decandolle observes, that this species, which is not found in Portugal, but grows on the Mediterranean side of France, Spain, and Italy, in Asia Minor, and in Barbary, would be better named pinus mediterranea. It composes the principal part of the forests of pines in the south-east of France, where Gouan and Gerard have

Mediterranean, and does not appear to have passed the Pillars of Hercules. We have met with these last pines on the slope of the Peak, near twelve hundred toises above the level of the ocean. In the Cordilleras of New Spain, under the torrid zone, the Mexican pines reach as high as two thousand toises. Notwithstanding the similarity of structure, that exists between the different species of the same genus of plants, each of them requires a certain degree of temperature and rarity in the ambient air, to attain its due growth. If in the temperate climates, and wherever snow falls, the constant heat of the soil is somewhat above the mean heat of the atmosphere, it is probable, that at the height of Portillo the roots of the pines draw their nourishment from a soil, in which, at a certain depth, the thermometer rises at most to nine or ten degrees.

The *fourth and fifth zones*, the regions of the retama and the gramina, occupy heights equal to the most inaccessible summits of the Pyrenees. It is the sterile part of the island, where heaps of pumice stone, obsidian, and broken lava, form impediments to vegetation. We have already spoken of those flowery tufts of alpine broom (spartium nubigenum), that form oases amidst a vast sea of ashes. Two herbaceous plants, the

confounded it with the pinus syslvestris. It comprehends the pinus halepensis, Mill., Lamb., and Desfont., and the pinus maritima, Lamb.

scrofularia glabrata, and the viola cheiranthifolia, advance even to the Malpays. Just above a turf scorched by the heat of an African sun, an arid soil is overspread by the cladonia paschalis, to which the herdsmen often set fire, that rolls to considerable distances. Toward the summit of the Peak, the urceolarea, and other plants of the family of the lichens, labour at the decomposition of the scorified matter. By this unceasing action of organic forces the empire of Flora extends itself over islands ravaged by volcanoes.

In traversing the different zones of the vegetation of Teneriffe, we see that the whole island may be considered as a forest of laurels, arbutus, and pines, of which the border has scarcely been cleared, and which contains in its centre a naked and rocky soil, unfit either for pasturage or cultivation. M. Broussonet observes, that the archipelago of the Canaries may be divided into two groups of islands. The first contains Lanzerota and Fortaventura, the second Teneriffe, Canary, Gomera, Ferro, and Palma. The appearance of the vegetation essentially differs in these two groups. The eastern islands, Lanzerota and Fortaventura, consist of extensive plains and mountains of little elevation; they have very few springs, and bear the appearance, still more than the other islands, of having been separated from the continent. The winds blow in the same direction, and at the same periods: the euphorbia

mauritanica, the atropa frutescens, and the arborescent sonchus, vegetate there in the loose sands, and serve, as in Africa, for food to camels. The western group of the Canaries presents a more elevated soil, more woody, and watered by a greater number of springs.

Though the whole archipelago contains several plants found in Portugal*, in Spain, at the Azores, and in the north-west of Africa, a great number of species, and even of genera, are peculiar to Teneriffe, to Porto Santo, and Madeira. Such are the mocanera, the plocama, the bosea, the canarina, the drusa, and the pittosporum. A form which may be called northern, that of the cruciform plants†, is already much rarer in the

* Mr. Willdenow and myself found, among the plants of the Peak of Teneriffe, the beautiful satyrium diphyllum (orchis cordata, Willd.), which Mr. Link discovered in Portugal. The Canaries have, in common with the Flora of the Azores, not the dicksonia culcita, the only arborescent heath found at the thirty-ninth degree of latitude, but the asplenium palmatum, and the myrica faya. This tree is met with in Portugal, in a wild state. Count Hoffmannsegg has seen very old trunks of it; but it was doubtful whether it was indigenous, or imported into this part of our continent. In reflecting on the migrations of plants, and on the geological possibility, that lands sunk in the ocean may have heretofore united Portugal, the Azores, the Canaries, and the chain of Atlas, we conceive, that the existence of the myrica faya in western Europe is a phænomenon at least as striking as that of the pine of Aleppo would be at the Azores.

† Among the small number of cruciform species contained

Canaries, than in Spain and in Greece. Still farther to the south, in the equinoctial regions of both continents, where the mean temperature of the air rises above twenty-two degrees, the cruciform plants are scarcely ever to be seen.

A question highly interesting to the history of the progressive display of organization on the Globe has been very warmly discussed in our own times, that of ascertaining whether the polymorphous plants are more common in the volcanic islands. The vegetation of Teneriffe is unfavourable to the hypothesis, that nature in new countries appears less subjected to constant forms. M. Broussonet, who resided so long at the Canaries, asserts, that the variable plants are not more common there than in the south of Europe. Ought it not to be presumed, that the polymorphous species, which are so abundant in the Isle of Bourbon, are owing rather to the nature of the soil, and to the climate, than to the newness of the vegetation?

I have now given a physical sketch of the island of Teneriffe; I have endeavoured to lay down precise notions respecting the geological constitution of the Canaries, the geography of plants peculiar to this archipelago, and their grouping at

in the Flora of Teneriffe, we shall here mention cheiranthus longifolius, l'Herit.; ch. fructescens, Vent.; ch. scoparius, Brouss.; erysimum bicorne, Aiton; crambe strigosa, and c. lævigata, Brouss.

different heights above the level of the ocean. Though I flatter myself with having thrown some light on objects, which have been so often discussed by other travellers, I think nevertheless, that the natural history of this archipelago still offers a vast field to inquiry. The commanders in scientific expeditions, of which England, France, Spain, Denmark, and Russia have furnished such brilliant examples, have in general been too hasty in quitting the Canaries. They have imagined, that these islands have been sufficiently described, because they are so nearly bordering on Europe; they have forgotten, that, in a geological point of view, the interior of New Holland is not more unknown, than the rocks of Lanzerota and Gomera, of Porto Santo and Terceira. We every year see a great number of naturalists traverse without any determined end the most frequented parts of Europe. Let us hope, that some among them, influenced by a love of science, and capable of pursuing a plan of several years, will devote themselves to the examination of the archipelago of the Azores, Madeira, the Canaries, Cape Verd Islands, and the north-west coast of Africa. By comparing observations made under the same point of view, in the Atlantic islands, and on the neighbouring continent, we shall attain exact information with respect to geology, and the geography of animals and plants.

Before we take leave of the old world to pass

into the new, I must speak of a subject which inspires a still greater interest, because it belongs to the history of man, and to those fatal revolutions, which have swept off whole tribes from the face of the earth. We inquire at the isle of Cuba, at St. Domingo, and in Jamaica, where is the abode of the primitive inhabitants of those countries? We ask at Teneriffe what is become of the Guanches, whose mummies alone, buried in caverns, have escaped destruction? In the fifteenth century, almost all the mercantile nations, especially the Spaniards and the Portuguese, sought for slaves at the Canary islands, as we seek them at present on the coast of Guinea*. The Christian religion, which in its origin was so highly favourable to the liberty of mankind, served as a pretext to the cupidity of Europeans. Every individual, made prisoner before he received the rite of baptism, was a slave. At this period, no attempt had yet been made to prove, that the blacks were an intermediary race between men and animals. The swarthy Guanche and the African negro were simultaneously sold in the market of Seville, without a question whether slavery ought to weigh only on men with a black skin and frizzled hair.

* The Spanish historians speak of expeditions made by the Huguenots of La Rochelle to carry off Guanche slaves. I have some doubt respecting these expeditions, which would have taken place posterior to the year 1530.

The archipelago of the Canaries was divided into several small states hostile to each other. Oftentimes the same island was subject to two independant princes, as happens in the islands of the South Sea, and wherever society is not highly advanced. The trading nations, influenced by that hideous policy which they still exercise on the coast of Africa, kept up intestine warfare. One Guanche then became the property of another, who sold him to the Europeans; several, who preferred death to slavery, killed themselves and their children. It is in this manner that the population of the Canaries had considerably suffered by the slave trade, by the depredations of pirates, and especially by a long period of carnage, when Alonzo de Lugo completed their conquest. What remained of the Guanches perished mostly in 1494, in the terrible pestilence called the *modorra*, which was attributed to the quantity of dead bodies left exposed to the air by the Spaniards after the battle of la Laguna. When a semibarbarous nation, robbed of its property, is compelled to live in the same country with a polished people, it seeks a retreat on the mountains and in the forests. This is the only refuge left to the choice of an islander. The nation of the Guanches was therefore extinct at the beginning of the seventeenth century; a few old men only were found at Candelaria and Guimar.

It is however consoling to find, that the whites

have not always disdained to intermarry with the natives; but the Canarians of the present day, whom the Spaniards denote by the familiar title of Islennos, have very powerful motives for denying this mixture. In a long series of generations time effaces the characteristic marks of a race; and as the dependants of the Andalusians settled at Teneriffe are themselves of a dark complexion, we may conceive, that the intermarriages cannot have produced a perceptible change in the color of the skins of the whites. It is very certain, that no native of pure race exists in the whole island; and some travellers, who may be otherwise relied on, are mistaken, when they assert, that their guides to the Peak were some of those slender and nimble footed Guanches. It is true, that a few Canarian families boast of their relationship to the last shepherd king of Guimar; but these pretensions do not rest on very solid foundations; and are renewed from time to time, when some Canarian, of a more dusky hue than his countrymen, is prompted to solicit a commission in the service of the king of Spain.

A short time after the discovery of America, when Spain was at the highest degree of its splendor, the gentle character of the Guanches was the fashionable topic, as we chaunt in our times the Arcadian innocence of the inhabitants of Otaheite. In both these pictures, the coloring is more gaudy than appropriate. When nations, wearied with

mental enjoyments, behold nothing in the refinement of manners but the germe of depravity, they are flattered with the idea, that in some distant region, in the first dawn of civilization, infant societies enjoy pure and perpetual felicity. To this sentiment Tacitus owed a part of his success, when he sketched for the Romans, subjects of the Cæsars, the picture of the manners of the inhabitants of Germany. The same sentiment gives an ineffable charm to the narrative of those travellers, who, at the close of the last century, visited the islands of the Pacific Ocean.

The inhabitants of those islands, too much vaunted, though heretofore anthropophagi, resemble, under more than one point of view, the Guanches of Teneriffe. We see both nations groaning under the yoke of feudal government. Among the Guanches this institution, which facilitates and renders a state of warfare perpetual, was sanctioned by religion. The priests declared to the people, "The great Spirit, Achaman, created first the nobles, the *achimenceys*, to whom he destributed all the goats, that exist on the face of the Earth. After the nobles, Achaman created the plebeians, *achicaxnas*. This younger race had the boldness to petition also for goats; but the supreme being answered, that this race was destined to serve the nobles, and that they had need of no property." This tradition was made, no doubt, to please the rich vassals of the shepherd kings.

Thus the *faycan*, or high priest, exercised the right of conferring nobility; and the law of the Guanches expressed, that every achimencey, who degraded himself by milking a goat with his own hands, lost his title to nobility. This law does not remind us of the simplicity of the Homeric age. We are astonished to see the useful labors of agriculture, and of a pastoral life, exposed to contempt at the very dawn of civilization.

The Guanches, famed for their tall stature, were the Patagonians of the old world; and historians exaggerated the muscular force of the Guanches, as, previous to the voyage of Bougainville and Cordoba, a colossal form was conferred on the tribe, that inhabited the southern extremity of America. I never saw Guanche mummies but in the cabinets of Europe; at the period of my journey, they were very scarce; a considerable number, however, might be found, if miners were employed to open the sepulchral caverns, which are cut in the rock on the eastern slope of the Peak, between Arico and Guimar. These mummies are in a state of desiccation so singular, that whole bodies, with their integuments, frequently do not weigh above six or seven pounds; or a third less than the skeleton of an individual of the same size, recently stripped of the muscular flesh. The conformation of the scull has some slight resemblance to that of the white race of the ancient Egyptians; and the incisive teeth of the Guanches are

blunted, like those in the mummies found on the banks of the Nile. But this form of the teeth is owing to art alone; and on examining more carefully the physiognomy of the ancient Canarians, able anatomists * have recognized in the cheek bones, and the lower jaw, perceptible differences from the Egyptian mummies. On opening those of the Guanches, remains of aromatic plants are discovered, among which the chenopodium ambrosioïdes is constantly perceived: the corpses are often decorated with small laces, to which are hung little discs of baked earth, that appear to have served as numerical signs, and resemble the *quippoes* of the Peruvians, the Mexicans, and the Chinese.

As the population of islands is in general less exposed to the effect of migrations than that of continents, we may presume, that, in the time of the Carthaginians and the Greeks, the Archipelago of the Canaries was inhabited by the same race of men, as were found by the Norman and Spanish conquerors. The only monument that can throw some light on the origin of the Guanches is their language; but unhappily there are not above a hundred and fifty words remaining, several of which express the same object, according to the dialect of the different islanders. Independent of

* *Blumenbach, Decas quinta Collect. suæ Craniorum diversarum Gentium illustr.* 1808, p. 7.

these words, which have been carefully noted, there are still some valuable fragments existing in the names of a great number of hamlets, hills, and valleys. The Guanches, like the Biscayans, the Hindoos, the Peruvians, and all the primitive nations, had named the places after the quality of the soil they cultivated, the shape of the rocks, the caverns that gave them shelter, and the nature of the tree that overshadowed the springs.

It has been long imagined, that the language of the Guanches had no analogy with the living tongues; but since the travels of Hornemann, and the ingenious researches of Marsden and Venturi, have drawn the attention of the learned to the Berbers, who like the Sarmatic tribes, occupy an immense extent of country in the north of Africa, we find, that several Guanche words have common roots with words of the Chilha and Gebali dialects*. We shall cite for instance the words:

Heaven, *in Guanche* —	Tigo;	*in Berberic,* Tigot.
Milk	Aho;	Acho.
Barley	Temasen	Tomzeen.
Basket	Carianas	Carian.
Water	Aenum	Anan.

I doubt whether this analogy is a proof of a common origin; but it is an indication of the ancient connexion between the Guanches and Berbers, a tribe of mountaineers, in which the Nu-

* Adelung und Vater, Mithridates, t. iii, p. 60.

midians, the Getuli, and the Garamanti are confounded, and who extend themselves from the eastern extremity of Atlas by Harutsch and Fezzan, as far as the Oasis of Siwah and Augela. The natives of the Canary Islands called themselves Guanches from *guan*, man; as the Tonguese call themselves *bye* and *donki*, which have the same signification as *guan*. Besides, the nations who speak the Berberic language are not all of the same race; and the description, which Scylax gives in his Periplus of the inhabitants of Cerne, a shepherd people of a tall statue and long hair, reminds us of the features, which characterise the Canary Guanches.

The greater attention we give to the study of languages in a philosophical point of view, the more we must observe, that no one of them is entirely distinct: the language of the Guanches * would appear still less so, had we any data re-

* According to the researches of Mr. Vater, the Guanche language offers the following analogies with the languages of nations very remote from each other: *dog* among the American Hurons, *aguienon;* among the Guanches, *aguyan; man*, among the Peruvians, *cari;* among the Guanches, *coran; king*, among the African Mandingoes, *monso;* among the Guanches, *monsey*. The name of the island of Gomera is found in that of Gomer, which designates a tribe of Berbers (*Vater, Untersuch. ueber Amerika*, p. 170). The Guanche words *Alcorac*, *God*, and *almogaron*, *temple*, seem to be of Arabic origin; at least in the latter tongue *almoharram* signifies *sacred*.

specting its mechanism and grammatical construction; two elements more important than the form of words, and the identity of sounds. It is the same with certain idioms, as with those organized beings, that seem to shrink from all classification in the series of natural families. Their isolated state is only so in appearance; for it ceases, when, on embracing a greater number of objects, we come to discover the intermediate links. The learned, who find Egyptians wherever there are mummies, hieroglyphics, or pyramids, will imagine perhaps, that the race of Typhon was united to the Guanches by the Berbers, real Atlantics, to whom belong the Tibboes and the Tuarycks of the Desert*: but it is sufficient here to observe, that this hypothesis is supported by no analogy† between the Berberic and Coptic languages, which are justly considered as a remnant of the ancient Egyptian.

The people who succeeded the Guanches descended from the Spaniards, and in a less degree from the Normans. Though these two races have been exposed during three centuries past to the same climate, the latter is distinguished by a whiter skin. The descendants of the Normans inhabit the valley of Teganana, between Punta de Naga and Punta de Hidalgo. The names of Grandville

* Voyage de Hornemann du Cairo à Mourzouk, t. ii, p. 406.

† Mithridates, t. iii, p. 77.

and Dampierre are still pretty common in this district. The Canarians are a moral, sober, and religious people; of a less industrious character at home, than in foreign countries. A roving and enterprising disposition leads these islanders, like the Biscayans and Catalonians, to the Philippines, to the Marian islands, to America, and wherever there are Spanish settlements, from Chili and la Plata to New-Mexico. To them we are in a great measure indebted for the progress of agriculture in those colonies. The whole Archipelago does not contain 160,000 inhabitants, and the *Islennos* are perhaps more numerous in the new continent, than in their own country. The following table indicates whatever relates to the statistics of this country.

Archipelago of the Canaries.	Surface in nautical square leagues.	Absolute population.				Relative population, or number of inhabitants to each squ. league in 1790.
		1678	1745	1768	1790	
Teneriffe . . .	73	49,112	60,218	66,354	70,000	958
Fortaventura . . .	63		7,382	8,863	9,000	142
Grand Canary . . .	60	20,458	33,864	41,082	50,000	833
Palma	27	13,892	17,580	19,195	22,600	837
Lanzerota . . .	26		7,210	9,705	10,000	384
Gomera . . .	14	4,373	6,251	6,645	7,400	528
Ferro	7	3,297	3,687	4,022	5,000	714
Total . . .	270		136,192	155,866	174,000	644

The enumerations of 1678, 1745, and 1768, have been published by Vieyra. The estimation of 1790 is by M. Ledru. The total population, according to Lord Macartney, was 196,500; of which there were 100,000 at Teneriffe, 40,000 at Canary, and 30,000 at Palma. The surfaces have been calculated for the first time, and very accurately, by Mr. Oltmanns*, from the charts of Borda and Varela. The vintage at Teneriffe yields from 20 to 24,000 pipes, 5000 of which are malmsey. The annual exportation of wine is from 8 to 9000 pipes. The amount of the harvest in the whole of the Archipelago in wheat is 54,000 fanegas, of a hundred pounds each. In ordinary years this crop is sufficient for the consumption of the inhabitants, who otherwise live on maize, potatoes, and French beans, *frisoles*. The cultivation of the sugar-cane and cotton is of little importance; the principal objects of commerce are wine, brandy, archil, and soda. The gross amount of the revenue, including the tax on tobacco, is 240,000 piastres.

* Extent of the surface of the Canaries more accurately expressed in geographic leagues of 15 to a degree: Teneriffe, $41\frac{3}{8}$; Fortaventura, $35\frac{1}{2}$; Canary, $33\frac{7}{8}$; Palma, $15\frac{1}{4}$; Lanzerota, $14\frac{1}{8}$; or, including the small neighbouring islands, $15\frac{1}{8}$; Gomera, 8; and Ferro, $3\frac{7}{8}$: total $153\frac{1}{4}$. It is astonishing, that Mr. Hassel, in his excellent work on the statistics of Europe, gives the Canaries a population of 420,000 inhabitants, and an extent of 358 square German miles. (*Stat. Umriss. Heft.* 1, 17.)

I shall not enter into any discussions of political economy relative to the importance of the Canary islands to the trading nations of Europe. Having long employed myself in statistical researches on the Spanish colonies, and being on terms of intimacy with persons who had held places of importance at Teneriffe, I had an opportunity, during my abode in Caraccas and at the Havannah, of collecting considerable information respecting the commerce of Santa Cruz and Orotava. But several distinguised persons having since visited the Canaries, they have obtained the same means of information as myself; and I do not hesitate to strike out from my narrative, what has been explained, with greater precision, in works that have preceded mine. I shall here confine myself to a few considerations, which will terminate the sketch I have just given of the Archipelago of the Canaries.

These islands have undergone the same fate as Egypt, the Crimea, and many other countries, respecting which travellers, who are anxious to elevate and surprise by contrasts, have been extravagant both in their praise and their blame. Some, landing at Orotava, describe Teneriffe as the garden of the Hesperides, and celebrate the amenity of the climate, the fruitfulness of the soil, and the richness of the cultivation; others, forced to sojourn at Santa Cruz, behold nothing in these Fortunate Islands but a country, naked, barren,

and inhabited by a stupid and miserable race. It appeared to me, that in this archipelago, as in all mountainous and volcanic countries, Nature has been very unequal in the distribution of her gifts. The Canaries are generally deficient in water; but wherever there are springs, artificial irrigations, or plentiful rains, the soil is highly fertile. The lower class of the people is laborious; but its industry is more active in distant colonies, than at Teneriffe, where it meets with obstacles, which a wise administration might progressively remove. Emigration would be diminished, if the uncultivated demesne lands were distributed among private persons, those which are annexed to the *majorats* of the great families were sold, and feudal rights were gradually abolished.

The present population of the Canaries undoubtedly appears inconsiderable, when compared with that of several countries of Europe. The island of Malta, the industrious inhabitants of which cultivate a rock almost destitute of mould, is seven times less than Teneriffe, and yet has twice the population: but writers, who are fond of painting in vivid colors the depopulation of the Spanish colonies, and who attribute the cause to the ecclesiastical hierarchy, forget that in every place, since the reign of Philip V, the number of inhabitants has obtained, in a greater or less degree, a rapid increase. The relative population is already greater in the Canaries, than in both Cas-

tiles, in Estramadura, and in Scotland. The whole archipelago exhibits a mountainous country, the extent of which is a seventh less than the surface of the island of Corsica: it supplies, however, the same number of inhabitants.

Though the islands of Lanzerota and Fortaventura, which are the least populous, export corn, while Teneriffe does not produce two thirds of its consumption, we must not conclude, that in this last island the number of inhabitants cannot increase for want of subsistence. The Canary islands are still remote from feeling the evils, that arise from too considerable a population, and of which Mr. Malthus has unfolded the causes with so much precision and knowledge. The misery of the people has considerably diminished, since the cultivation of potatoes * has been introduced, and since they have begun to sow more maize, than wheat and barley.

The inhabitants of the Canaries exhibit traits characteristic of a people, who are at the same time mountaineers and islanders. In order to estimate them truly, it is not enough to behold them in their own country, where powerful obstacles prevent the display of industry; we must study them in the plains of the province of Caraccas, on the ridge of the Andes, in the burning plains of the Philippine

* Tessier and Desautoy, on the Agriculture of the Canaries, *Mem. de l'Inst.* t. i, p. 250 et 279.

islands, and wherever isolated in uninhabited countries they have had occasion to display that energy and activity, which are the true riches of a planter.

The Canarians are fond of considering their country as forming part of European Spain, and they have added some portion to the riches of Castilian literature. The names of Clavijo, author of the Pensador Madritense, of Vieyra, Yriarte, and Betancourt, are honourably distinguished in the scientific and in the literary world. The Canarians are endowed with that liveliness of imagination, which characterizes the inhabitants of Andalusia and Grenada; and we may be led to hope, that, at some future period, the Fortunate islands, like every other climate of the Globe, either where man reposes on the lavish bounties of Nature, or shrinks from the severity of her frown, will inspire the muse of some native poet.

END OF VOL. I.

TABLES.

1 toise = 6 feet 4·736 inches
1 foot (pié du roi) = 12·789
1 metre = 3 3·371

Table of Degrees of the Centigrade Thermometer, from the point of boiling water to that of freezing mercury, reduced to Fahrenheit's scale.

Centigr.	Fahren.	Centigr.	Fahren.	Centigr.	Fah ren:
100	212	78	172·4	56	132·8
99	210·2	77	170·6	55	131
98	208·4	76	168·8	54	129·2
97	206·6	75	167	53	127·4
96	204·8	74	165·2	52	125·6
95	203	73	163·4	51	123·8
94	201·2	72	161·6	50	122
93	199·4	71	159·8	49	120·2
92	197·6	70	158	48	118·4
91	195·8	69	156·2	47	116·6
90	194	68	154·4	46	114·8
89	192·2	67	152·6	45	113
88	190·4	66	150·8	44	111·2
87	188·6	65	149	43	109·4
86	186·8	64	147·2	42	107·6
85	185	63	145·4	41	105·8
84	183·2	62	143·6	40	104
83	181·4	61	141·8	39	102·2
82	179·6	60	140	38	100·4
81	177·8	59	138·2	37	98·6
80	176	58	136·4	36	96·8
79	174·2	57	134·6	35	95

Centigr.	Fahren.	Centigr.	Fahren.	Centigr.	Fahren.
34	93·2	9	48·2	16	3·2
33	91·4	8	46·4	17	1·4
32	89·6	7	44·6	18	—0·4
31	87·8	6	42·8	19	2·2
30	86	5	41	20	4
29	84·2	4	39·2	21	5·8
28	82·4	3	37·4	22	7·6
27	80·6	2	35·6	23	9·4
26	78·8	1	33·8	24	11·2
25	77	0	32	25	13
24	75·2	—1	30·2	26	14·8
23	73·4	2	28·4	27	16·6
22	71·6	3	26·6	28	18·4
21	69·8	4	24·8	29	20·2
20	68	5	23	30	22
19	66·2	6	21·2	31	23·8
18	64·4	7	19·4	32	25·6
17	62·6	8	17·6	33	27·4
16	60·8	9	15·8	34	29·2
15	59	10	14	35	31
14	57·2	11	12·2	36	32·8
13	55·4	12	10·4	37	34·6
12	53·6	13	8·6	38	36·4
11	51·8	14	6·8	39	38·2
10	50	15	5	40	40

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